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Crum Woods Boardwalk

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Crum Woods Boardwalk
E90 Senior Design Project Final Report

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Advisors: Professor Matt Zucker, Professor Fiona O'Donnell

Spring 2023

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1.0 Abstract

This project combines civil and environmental engineering concepts to design, test, and construct a boardwalk in the Crum Woods in order to improve the Crum Woods trail system for the broader Swarthmore community. This project is motivated by a dedication to serve Swarthmore's community, an appreciation for the Crum Woods trails as cross country runners, and past work experience on conservation crews. The goal is to make the Crum Woods' trails more sustainable and less susceptible to erosion.

The area of focus for this project is a section of trail that commonly floods and becomes too muddy for use, causing pedestrians to have to walk off trail in order to pass. The solution to this problem is to design and construct a raised boardwalk in order to provide a stable and sustainable walking surface, preventing social trail formation and trail widening. The project involves interaction with the Pennsylvania Department of Environmental Protection (DEP), a local professional engineer, and other government agencies to approve the project for installation and to ensure legal compliance. Designs follow U.S. Forest Service trail construction specifications.

Parallel with the design process, a structural analysis is completed to validate specifications and design choices, ensuring that the final structure is safe for pedestrian loads. Mechanical, civil, and environmental engineering concepts inform our design, as well as skills gained from our personal work experiences. This project is a collaborative effort as well; assistance from the Swarthmore Arboretum and community including Director of Grounds Jeff Jabco and Horticultural Supervisor Lars Rasmussen was invaluable.

2.0 Motivation

The initial idea for this project grew out of our frequent use of the Crum Woods trails as members of the Swarthmore cross country team. These trails are essential to the team, as they provide a soft surface for training throughout the year. Thus, improving trail accessibility and sustainability seemed like a fitting E90 project that would give back both the cross country team and to the broader Swarthmore community.

In addition, we have both dedicated the last three years to conservation work outside of college by working for the Rocky Mountain Youth Corps in Colorado and Appalachian Conservation Corps in Virginia. These AmeriCorps programs facilitated knowledge of trail work, conservation, and sustainability through hands-on manual labor with the US Forest Service, National Park Service, and Bureau of Land Management. In pursuing this project, we want to utilize the skills gained from our wilderness construction experience in order to benefit the Swarthmore community and extend the life and usability of Swarthmore's very own trail system.

3.0 Project Site

The spot identified for improvement is a section of trail below the Strath Haven Condominiums on the Southern tip of the Crum Woods trail network. This section is usually muddy and frequently floods, becoming nearly impassable during wet periods of the year. The section identified spans about 200 feet, all of which could be greatly improved. This project addresses a 72 foot section of the impacted trail with the installation of a boardwalk, also known as a puncheon structure. Location and images of the site itself are shown below in Figures 1, 2, and 3.



Figure 1. Images of flooded section of trail (photos taken by Lars Rasmussen)

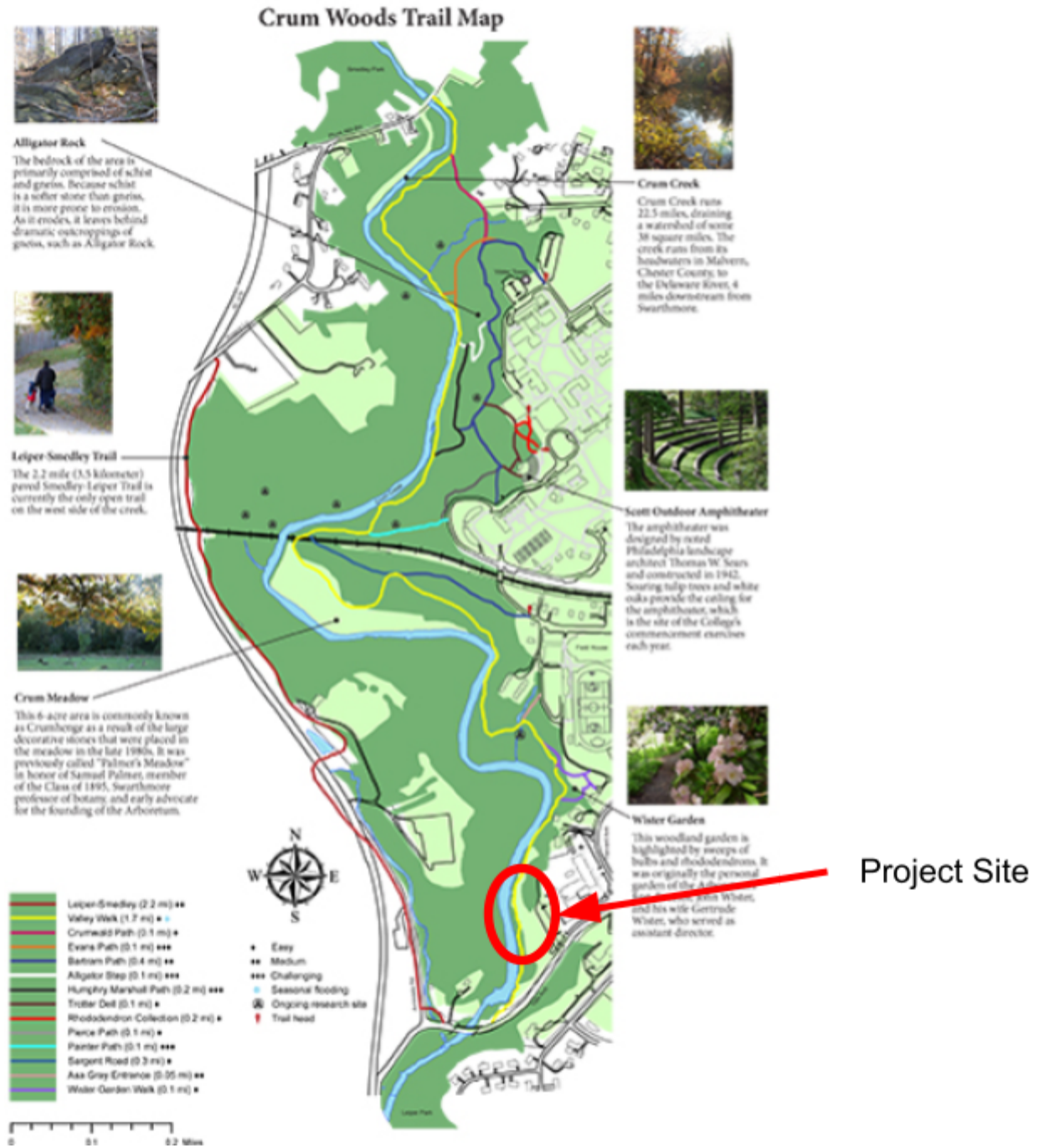


Figure 2. Project site location identified on map of Crum Woods from Swarthmore College [1]



Figure 3. Aerial view of approximate location and length of trail needing improvement; Strath Haven Condominiums appear at right of photo [2]

4.0 Considerations and Requirements

4.1 Community

First and foremost, community input for this project is essential as our engineering design impacts users of the Crum Woods trails. This project is a collaborative effort with the Swarthmore Arboretum and the Crum Woods Stewardship Committee. All aspects of the project are communicated to and approved by these stakeholders. Community members had shared complaints that the project site was an area of concern due to the flooding. To address these concerns, we proposed the installation of a boardwalk.

When designing a boardwalk, it is important to consider design loads for pedestrian use, the existing trail width, cost and time considerations, habitat impact, post-construction maintenance and upkeep, and more [3]. Permitting, material acquisition, and construction are all time intensive processes. During the construction phase, factors like weather and trail conditions also affect the time table for building. These considerations are important to recognize as part of the engineering design process.

4.2 Permit Process

According to Chapter 105 of the Pennsylvania Code, a permit is required for the construction or modification of culverts and bridges, including any structure that infringes on waterway management [4]. Furthermore, this section of trail sits next to the Crum Creek in an area that is labeled by FEMA as flood zone AE, meaning that it has a one percent or greater chance of inundation or flooding annually [5]. Because of this designation, building in this region requires special permission from the district in which it is located. Thus, there is an extensive permitting process that must be undergone before the construction process can begin.



Figure 4. FEMA flood zone map of Swarthmore [6]

In order to determine which type of permit to apply for, we were advised by Mike McGraw, a Senior Wildlife Biologist for RES that partners with the college. The first course of action he advised us to take was to obtain clearance from the Pennsylvania Natural Heritage Program (PNHP). This entails the successful application for and receipt of a Pennsylvania Natural Diversity Inventory (PNDI), “a dynamic inventory system of Pennsylvania rare and threatened species maintained in a cooperative effort between the Western Pennsylvania Conservancy, the Pennsylvania Bureau of Forestry, and The Nature Conservancy” [7]. The inventory process entailed the submission of a project narrative and a delineation of project location and area of disturbance through PNHP’s online portal.¹ Then, we were issued a receipt indicating the potential impacts of the project and the government agencies under whose purview those impacts fall.

Next, we organized a pre-application meeting with the DEP. We met with representatives from the DEP, including Project Manager Govind Daryani, Biologists Joshua Hassler and Emily Ashberry, and US Army Corps of Engineers representative David Caplan. In this meeting held on February 2, 2023, it was determined our project would require a GP-11 Permit for the “Maintenance, Testing, Repair, Rehabilitation, or Replacement of Water Obstructions and Encroachments” of an existing trail. Next steps in the permitting process were also outlined, including the receipt of a successful PNDI, delineation of project limits of disturbance, production of standard design drawings approved by a professional engineer, and submission of a wetlands impact statement in our final permit packet. The notes from this meeting are attached in Appendix A.

A meeting was also arranged with Ross Bickhart, a professional engineer who regularly works with the College, who advised us on the permit application process. With his help, we

¹ The PNDP online portal can be accessed at the following URL: <https://conservationexplorer.dcnr.pa.gov/>

were able to better understand the permit application requirements, and he showed us an example permit application to follow. He also advised us on what information to include in our Erosion and Sediment Control Plan. In addition, Ross assisted in our boardwalk design and certified the end result after an iterative design process. The developed Standard Design Drawings and Erosion and Sediment Control Plan are in Section 5 and 7, respectively, of Appendix B.

Through further correspondence with representatives of the two agencies identified on our PNDI receipt, the Pennsylvania Department of Fish and Wildlife (PDFW) and the Pennsylvania Fish and Boat Commission (PFBC), we were granted letters of approval from each, completing our successful PNDI package. We submitted these letters and the PNDI receipt as part of our final permit application to the Pennsylvania Department of Environmental Protection (DEP). The PNDI receipt is found in Section 8 of Appendix B.

Our final submitted permit packet is the entirety of Appendix B. The permit application was approved on April 10, 2023 with permit identifier GP112301223-009. It was reviewed and approved by Ms. Shabnam Dhull with the DEP. In addition, the Erosion and Sediment control plan was “determined to adequately satisfy those requirements of 25 PA Code Chapter 102 to minimize the potential for accelerated erosion and sedimentation to the waters of the Commonwealth.”

5.0 Boardwalk Design

5.1 Technical Description

The proposed design for this project to build a puncheon structure follows specifications from the United States Forest Service (USFS) which are included in Appendix A [8]. Additionally, design descriptions outlined in the Trail Construction and Maintenance Notebook were utilized [9]. In order to understand the design, one must know some trail terminology.

Mud sills are the stout beams that underlie the puncheon structure, maintaining contact with the ground, installed at intervals perpendicular to the trail. These secure the structure in the ground and must be installed level in order to ultimately provide a level walking surface, or tread. The sills are generally installed in a hole footprint that has been dug in the ground, and anchored by driving steel rebar through each sill into the earth below. The maximum distance between adjacent mud sills is standardized at 6 feet.

In contact with the top of the sills, running parallel to the trail, stringers are installed. These beams intersect the mud sills perpendicularly. They are connected to the mud sills with 8-12 inch galvanized lag screws or timberloks. Stringer spacing is constrained by the desired width of the tread. Next, the actual walking surface, also known as decking, is installed on top of the stringers, aligned in a row perpendicular to the trail. The decking is fastened using epoxy-coated wood screws that attach each decking plank to the stringers on which it rests. The last part of the USFS design is the curb, the small running beams that lie on each side of the walking surface. Figures 5-8 below display an example of a puncheon structure Emily built with Rocky Mountain Youth Corps for the USFS Dillon Ranger District in the Summer of 2020.



Figure 5. mud sills in ground



Figure 6. Stringers placed on mud sills



Figure 7. Installation of decking



Figure 8. Installation of natural timber puncheon

5.2 Material Selection

In the fabrication and installation of outdoor structures like this one, material selection is important to ensure lasting quality and structural integrity. Weather-resistant lumber and corrosion-resistant fasteners increase both the longevity and safety of the final structure. Research has shown that non treated timbers have a longevity of 1/20th to 1/5th of that of treated timbers [10]. Because of this stark difference, treatment is essential for most structural, outdoor applications.

Especially in this project, because we are building within the floodplain, choosing lumber with optimal treatment is important. USFS guidelines recommend using pressure-treated Southern Pine for all ground-contact applications when untreated wood high in heartwood decay resistance is not available. In this case, due to budget and sourcing constraints, we chose UC4 (use case as detailed in USFS's Sustainable Trail Bridge Design Document), No. 2,

ground-contact Southern Yellow Pine (SYP) [10]. This choice will result in members resistant to normal seasonal conditions, insects, and decay fungi.

Though wood treatment provides the benefit of increased longevity and safety for structure users, there is also the potential for preservative chemical leaching into groundwater and soil. However, the copper-based chemicals used in modern-day treatment were found in a 2000 worst-case study by the USFS and United States Department of Agriculture to not pose a significant threat to local biodiversity. Though the concentrations of preservatives increased measurably in water and sediment surrounding the experimental site, no impact was found on local taxa in any of the measures applied [11].

5.3 Design Workflow

In order to submit our permit to the PADEP, we were required to attach “Site Specific and/or Standard Drawings ... prepared by a registered professional engineer and ... affixed with their seal and certification” [12]. To satisfy this requirement, we underwent an iterative design process in collaboration with Ross Bickhart, a registered professional engineer who has worked on previous college infrastructure upgrades, including the 2022 Crum Swale project. After a site visit with director of grounds Jeff Jabco, during which we took length and spacing measurements for mud sill positioning, as well as measurements of the turn angle of the trail section, we drafted an initial design in Fusion 360.

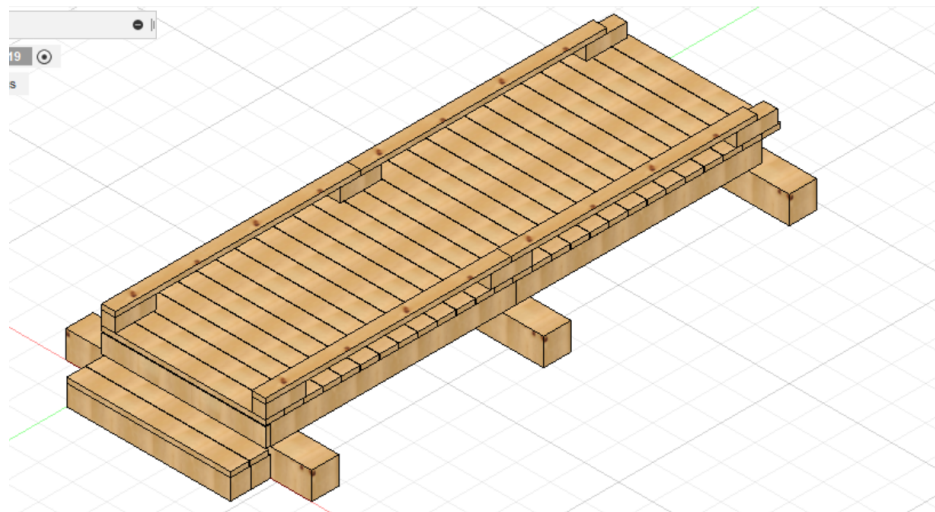


Figure 9. Screenshot of Fusion 360 boardwalk design section

From this 3D model, we produced structural drawings using the built-in model-to-drawing feature. We sent these initial drawings to Ross, who recommended alterations to the design in order to bring them to the standard of certification. We repeated this iterative design process several times, making changes to our existing drawings and producing detailed drawings including the turn design, step design, fasteners, and curbing design. Refer to Appendix B Section 5 for the final drawings certified by Ross.

During this process, we expanded our knowledge and skills in Fusion 360 design. Because much of the boardwalk is symmetrical and uses the same size and shape materials, the move/copy function was highly utilized to speed up the design process. We also learned how to import fasteners into our 3D model and change the appearance of the material. One future consideration for a similar project would be to perform a stress test in simulation software; however, Fusion 360 simulation software is currently limited and does not support wood materials.

6.0 Structural Analysis

In order to validate our design, there are two important properties of wood to analyze: the material's serviceability and strength. Serviceability refers to the displacement or deflection of a wooden member. The following analysis outlines the deflection calculations for a decking board above a set of stringers under human load. The initial draft design only utilized two stringers, which resulted in a deflection of 1.53in. To minimize this deflection, a third stringer was added to the design, reducing the deflection to 0.19in. To simplify deflection calculations for the addition of a third stringer, the length of the span was halved.

6.1 Deflection Calculations

The first deflection calculation was applied to a 6x2" decking board across a stringer span of 4 ft with a pedestrian load capacity. Note that the actual size of a nominal 2x6" board is 1.5x5.5". The load capacity is assumed to be 90 lb/ft² as according to the "AASHTO LRFD Guide Specification For The Design of Pedestrian Bridges" [13]. The Modulus of Elasticity for No. 2 Southern Yellow Pine is assumed to be 1,600,000 psi according to "SPIB Grading Rules and AWC National Design Specification" [14]. The calculation of deflection is derived from Russell C. Hibbeler's textbook, *Engineering Mechanics: Statics* [15].

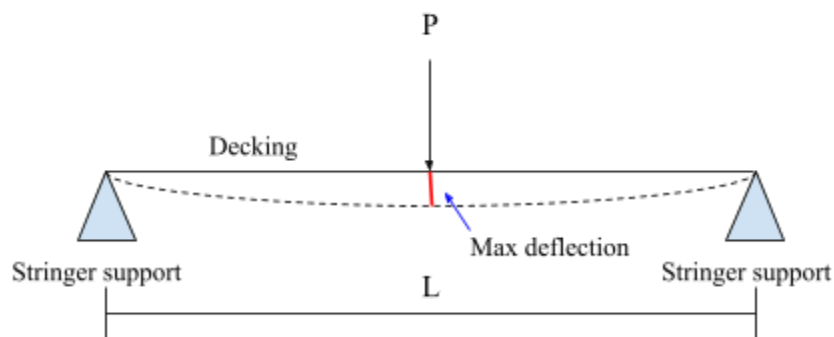


Figure 10. Diagram of decking beam deflection

Assumed load capacity of pedestrian: 90 lb/ft²

Length of span between stringers: $L = 4$ ft

Dimensions of Decking: 5.5 in x 1.5 in

Modulus of Elasticity: $E = 1.6$ million psi

Calculation of moment of inertia for rectangular beam:

$$I = \frac{1}{12}bd^2 = \frac{1}{12}(5.5\text{''})(1.5\text{''})^2 = 1.55\text{ in}^4$$

Calculation of point load from distributed load:

$$90 \frac{\text{lb}}{\text{ft}^2} \times \frac{1\text{ft}^2}{144\text{ in}^2} \times 5.5\text{ in} \times 4\text{ ft} \times \frac{12\text{ in}}{1\text{ ft}} = 165\text{ lbs}$$

Maximum deflection equation:

$$\delta_{max} = \frac{PL^3}{48EI}$$

Plugging in values, $\delta_{max} = 1.53\text{ in}$

Based on this deflection calculation, it was determined that a third stringer would be needed to minimize the allowed deflection for our design. With a span length between stringers at 2 feet ($L = 2$), δ_{max} becomes 0.19 in. This is an appropriate design deflection.

6.2 Strength Testing

Another important aspect of structural design is strength. We must consider whether the load inducing normal stress due to bending will be less than the yield stress and stay within the elastic range. The elastic range is when a material is under stress, but only to a point of temporary deformation. In order to answer this question, we must find the Modulus of Rupture (MOR) to determine at what point the timber will yield and have permanent deformation.

$$\text{MOR Equation: } MOR = \frac{3P_{max}L}{2bh^2}$$

Experimentally, we can test for the MOR following the American Society for Testing and Materials (ASTM) standard procedure designated by D198-13, the “Standard Test Methods of Static Tests of Lumber in Structural Sizes” [16]. Following this procedure, the maximum load, maximum deflection, and MOR can be calculated.

6.2.1 Testing Procedure

To experimentally test the strength of pressure-treated members like the ones employed in our design, we procured some sample standard decking boards from the Engineering Machine Shop. For testing, we used three four-foot length sections of 2x4” pressure-treated No.2 SYP. In each case, we mounted the board on the Universal Testing Machine (UTM) as shown in Figure 11.



Figure 11. Experimental testing setup on the UTM; four-foot length 2x4” decking board mounted with two supports and load applied at the center.

After mounting, we initialized the UTM and set the deflection rate at 0.50 in/min. The ASTM guidelines on speed of testing (section 9.3) call for the loading to “progress at a constant deformation rate such that the average time to maximum load for the test series shall be at least 4 min” [16]. In order to find the appropriate deflection rate, the following calculations were made using an assumed MOR at 12,800 psi [17].

First, solve for the theoretical maximum load:

$$MOR = \frac{3P_{max}L}{2bh^2} = \frac{3P_{max}(48in)}{2(5.5in)(1.5in)^2} = 12,800 \text{ psi}$$

$$P_{max} = 2,200 \text{ lb}$$

Next, calculate the theoretical deflection:

$$\delta_{max} = \frac{PL^3}{48EI} = \frac{(2200)(48)^3}{48(1600000)(1.55)} = 2.04 \text{ in}$$

Divide the deflection by 4 min:

$$\text{Optimum rate of deflection} = 0.51 \text{ in} \approx 0.50 \text{ in}$$

Using this rate of deflection, the UTM increased its load on each of the decking boards until failure occurred at some P_{max} , the results of which are recorded in Table 1 below. The deflection at which failure occurred, δ_{max} , is also recorded in Table 1 for each board. Figure 12 displays two of the decking boards at failure.

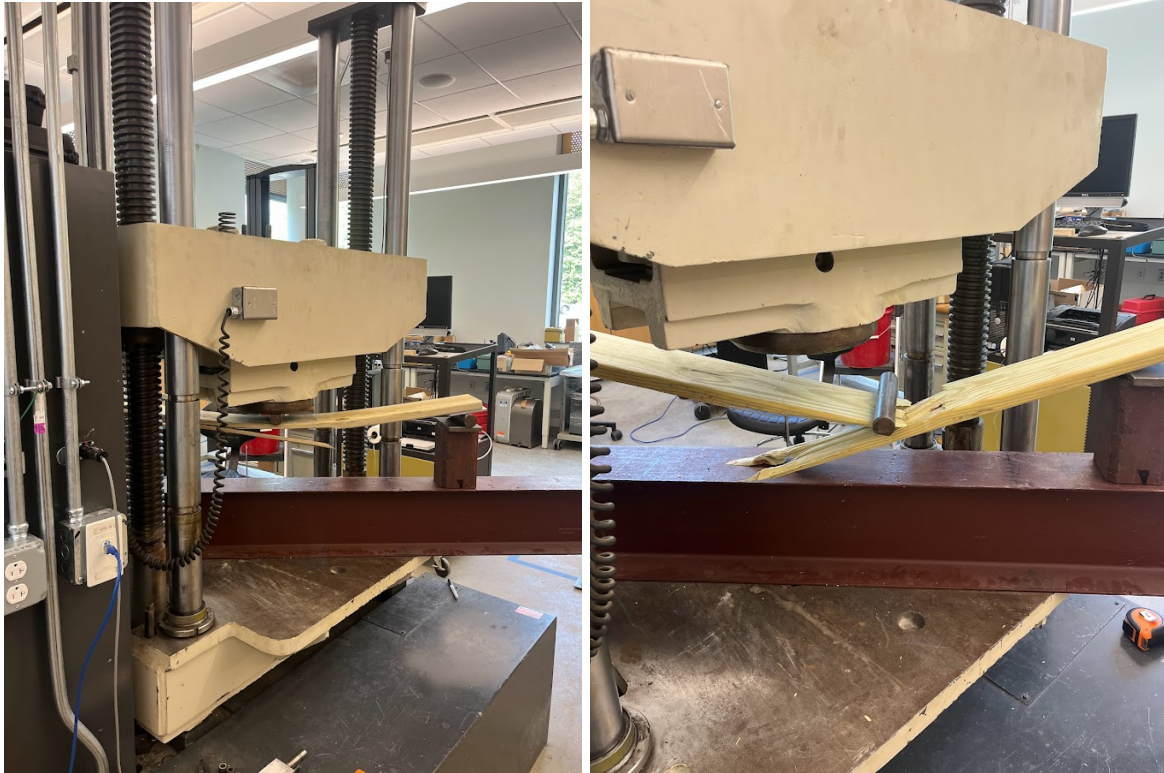


Figure 12. Images of decking boards at failure in the UTM

6.2.2 Results

From our in-lab testing, we generated plots of load vs. deflection for the three different boards we tested. In each plot (Fig. 13-15), the load can be seen steadily increasing until failure, at which point it drops sharply. Smaller undulations in the load curve, most pronounced in Fig. 14, represent fibers or fiber clusters in the board failing; in the lab setting we heard snapping noises at these times.

The values in Table 1 are derived directly from the data where P_{max} is the maximum load value applied to each board, and δ_{max} is the deflection at which this P_{max} is reached. From these data, we calculated the MOR for each board using the MOR Equation in section 6.2.

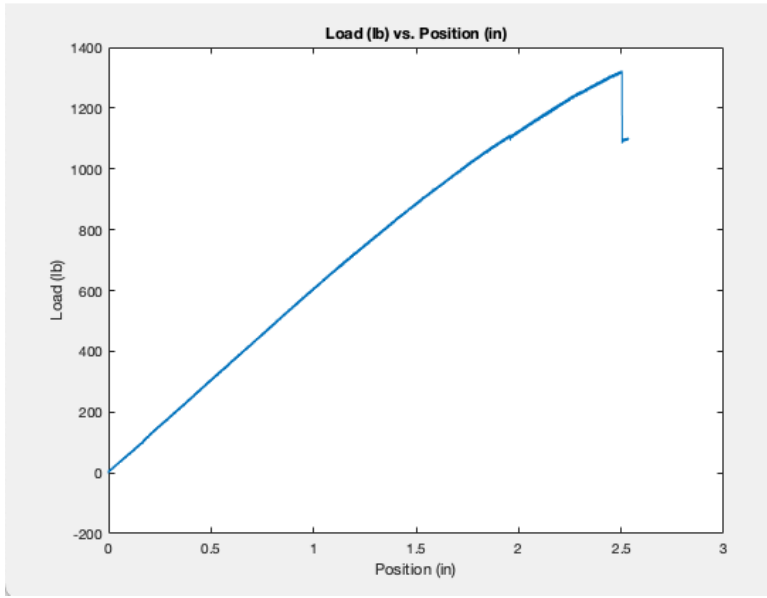


Figure 13. UTM test results plot of Load (lb) vs. Position (in) of Board 1

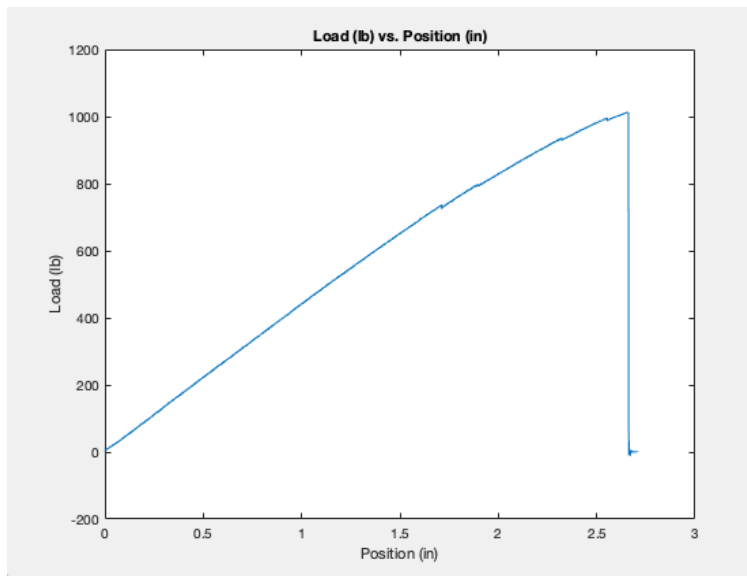


Figure 14. UTM test results plot of Load (lb) vs. Position (in) of Board 2

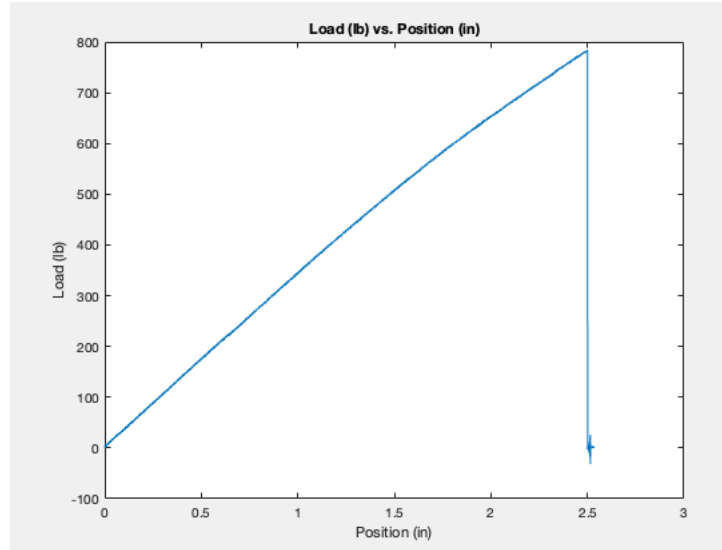


Figure 15. UTM test results plot of Load (lb) vs. Position (in) of Board 3

Table 1. P_{max} , δ_{max} , and MOR of each of the three boards tested

	Board 1	Board 2	Board 3
P_{max} (lb)	1323	1013	784
δ_{max} (in)	2.54	2.71	2.53
MOR (psi)	7056	5402	4181

These MORs were all within the published estimated range for structural wood members, which fall between 5,000 to 15,000 psi [18]. The average MOR for Southern Pine boards is at around 46.1 mPa, or 6686 psi [19]. Board 2 and board 3 sit below this average; however they are still within the range of serviceable values for Southern Pine. The distribution in strength across the three boards may be due to defects or knot placement in each individual board which can have an effect on a board's overall strength [20]. The moisture content of the boards was also not measured, which can also affect a board's strength [21].

Importantly, these strength tests further validated our design, especially our choice to use three stringers instead of two. The maximum loads on these boards greatly exceed even worst-case pedestrian load. With an actual maximum decking span of two feet instead of the four used in our testing (as a result of the third stringer), our design is well within serviceable strength and deflection limits for pedestrian loads.

7.0 Build Methodology

7.1 Materials

Refer to the Cost Analysis section and Standard Drawings in Appendix B for more detailed information on materials. Overall quantity of boardwalk parts are listed below.

- 13 mud sills (8x8 SYP treated ground contact)
- 38 stringers (6x6 SYP treated ground contact)
- 155 decking boards (2x6 SYP treated ground contact)
- 24 sections of curbing (4x4 and 2x4 SYP treated ground contact)
- 156 8" length $\frac{3}{8}$ " dia. galvanized hex lag screws
- 1000 #10 x 3- $\frac{1}{2}$ " galvanized deck screw
- 52 .220x6" timber screw exterior grade double barrier T-40 bit
- 30 #5 rebar at 3'

Tools borrowed from the Engineering Machine Shop, Facilities, and Arboretum:

- Digging tools (pick-mattock, shovel, rock bar, cutter-mattock)
- Double jack
- Way to transport materials to the site (e.g. truck)
- Chainsaw to cut 8x8" timber
- Chop saw
- Drills and bits ($\frac{1}{2}$ ", $\frac{3}{8}$ ", $\frac{5}{8}$ ", etc.)
- Levels
- Tape measure
- Flagging tape
- String Line
- PPE: Hardhats, Gloves, Eye Protection
- First Aid Kit

7.2 Risk Management

In order to minimize risk at the work site, a risk management plan was developed and approved by the College before construction began. Both Jonah and Emily were trail crew leaders for summer conservation crews, and so they are adequately trained in trail construction safety and tool management, as well as being certified in Wilderness First Aid. Summer job responsibilities included walking through a Job Hazard Assessment (JHA) before each work project, leading a pre-work stretch circle, ensuring use of proper personal protective equipment (PPE), and going over how to carry, use, and safely store (CUSS) all tools used in the construction process.

For this project, we will follow these standard risk management techniques to ensure safety on the worksite. In addition, J. Johnson, Lars Rasmussen, and other Swarthmore Grounds employees have volunteered to help supervise. Student volunteers will be walked through a JHA, trained on proper ergonomics and technique, and required to use standard PPE. The following outline describes potential hazards and risk management strategies.

Some of the risks we identified are:

1. Injury from improper ergonomics or overuse
2. Strain from carrying heavy materials
3. Swinging tools for digging/pounding rebar
4. Sharp tools like drills, saws
5. Uneven terrain, weather, or other environmental risk

Ways to mitigate risks:

1. Go over JHA and tool CUSS before beginning work
2. PPE required on the worksite at all times
3. Break up tasks or take turns so one person is not doing the same task too long – i.e., partners or groups of 3 could switch off every couple of minutes of digging and take turns leveling or moving/hauling materials
4. Multiple people should help to move materials safely to distribute the weight and prevent over-exhaustion
5. Maintain safe distance between people working with trail tools – if someone needs to pass someone else working in a section, they must communicate and make sure they are not in the “blood bubble” while passing a person using a tool
6. Take water and snack breaks regularly
7. In case of inclement weather, pause work until better conditions and seek shelter if thunderstorm arises

7.3 Build Process

Pre-build:

After ordering materials, the High Bay in Singer Hall was cleared for material delivery to have a convenient and dry storage space for the timber. With J. Johnson’s supervision, the boards are cut to the correct sizes using the chop saw from the machine shop (the boards come in 12-16 ft lengths which are cut to the various lengths as indicated on the Standard Drawings). J assisted in chainsawing the 8x8” mud sills. A power drill with $\frac{5}{8}$ ” bit is used to pre-drill the mud sills for insertion of rebar, centered 6” from the each end. Once all materials are cut to size and pre-drilled, they are transported to the work site with the help of J or Grounds staff. In addition to preparing the timber, trail tools, PPE, and the first aid kit are gathered.

Step 1: Mud Sill Installation

At the work site, on the trail below Strath Haven Condominiums, we first outline the work site and locations of mud sills. To do this, stakes are placed at the opposite ends of each boardwalk section, with a center string line running the length of the section. A 6 ft ledger board is used to represent the footprint of each mud sill, with stakes placed on either side of the board. Using the string line, a string level, and the stakes, the depths of each ledger board are measured

and recorded. This is in order to properly level each mud sill. To ensure that the ledger boards are straight, the length of the diagonals between boards is measured and corrected until equivalent.

To level the mud sills, we have to clear small sections of the trail to the right depth to flatten the area across the 6ft span. There are 13 mud sills total. To level the surface, digging tools are used to remove soil. The entirety of each mud sill footprint needs to be flat, in addition to matching the height of every other mud sill. Leveling tools are used to adjust and alter the soil heights properly.

After each mud sill foundation is complete, the mud sills are placed and three-foot #5 rebar stakes are pounded into the pre-drilled holes. This particular task is challenging as there may be rocks or roots underground that must be split. To pound the rebar, a double jack, also known as a sledge hammer, is used.

Step 2: Stringer Installation

Once the mud sills are set, the stringers must be cut to size to span the distance across each consecutive mud sill. In the High Bay, stringers are cut at varying lengths; most are cut to 6 ft, but the turn requires three different lengths at specific angles as denoted in the turn design (as found in Appendix B, Section 5). After sizing the stringers, two lag screw holes are pre-drilled in each end of the boards with a 1/2" counterbore and transported to the work site. On site, three stringers are laid evenly spaced across the center 4-foot span of the mud sills. The stringers are fastened down to the sills with a drill and 8" lag screws, again shown in the boardwalk design drawings.

Step 3: Decking Installation

Next, the 2x6"-4' decking boards are transported to the project site. They are laid out with a 1/8" spacing on top of the stringers and affixed with 3-1/2" wood screws drilled through each board and into the stringer below.

Step 4: Curbing

Finally, the curbing is installed using 2x4"-6' and 4x4"-1' timber. The 4x4"-1' sections are spaced 6 ft apart, starting at one end of the boardwalk. These are secured through the decking to the stringer using a 6" timber screw. Then the 2x4"-6' sections are secured on top of the spacers using 3-1/2" galvanized wood screws. The curbing lengths are modified for the turn section of the boardwalk.

For further guidance on boardwalk construction, refer to Chapter 15 of the California State Parks Trails Handbook [22], or another trail construction manual.

7.4 Maintenance

The Crum Woods Stewardship Committee will be responsible for the continued maintenance of the boardwalk. The lifespan of this boardwalk is predicted to be 15-30 years,

based on similar trail construction projects [18]. As weathering occurs, maintenance will be required to check for rotting and to ensure the stability of all boards. Decking is the most likely to need replacement, which can easily be removed and replaced following the same construction methods outlined above.

8.0 Laser-Engraved Plaque Design

In order to commemorate our work, we designed a plaque to secure to the boardwalk with an engraved description and acknowledgement. The CAD model of the plaque is shown below in Fig. 16; it will be fabricated from wood in the Swarthmore Makerspace using the laser engraver.

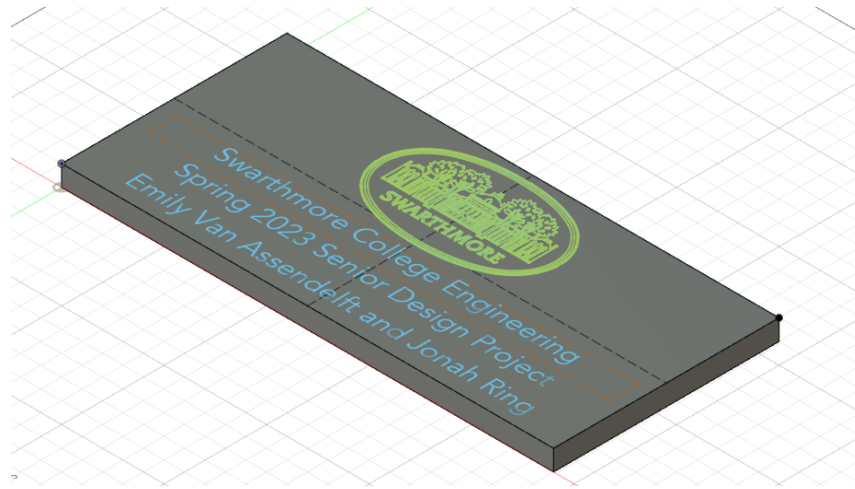


Figure 16. Plaque design view from Fusion 360; the laser-engraved plaque will be affixed to the finished boardwalk

9.0 Cost Analysis

Funding for this project was provided by the Crum Woods Stewardship Committee, in addition to the \$800 budget provided by the engineering department. This funding was used to obtain permits and purchase materials and other supplies not already available through the Grounds Department or Engineering Machine Shop. Table 2 below outlines the project costs.

Table 2. Crum Woods Boardwalk Project cost

Product	Quantity	Unit Price	Total
8x8-12' Southern Yellow Pine (SYP) treated ground contact	6	151.00	906
8x8-16' Southern Yellow Pine (SYP) treated ground contact	1	199.95	199.95
6x6-12' SYP treated ground contact	19	53.50	1016
2x6-12' SYP treated ground contact	52	13.40	696.80

2x4-12' SYP treated ground contact	12	9.55	114.60
4x4-12' SYP treated ground contact	3	24.20	72.60
8" length 3/8" dia. galvanized hex lag screws	156	2.54	396.24
#10 x 3-1/2" galvanized deck screw	1000	8.99	179.80
.220x6" timber screw exterior grade double barrier T-40 bit	52	49.60	49.60
Delivery Charge	1	75.00	75.00
#5 rebar at 20'	2	24.84	49.68
Additional trail tools (pick-mattock, double jack)	2	34.98	69.96
GP-11 Permit	1	\$750 + \$800/.1 acre	830
PNDI Search Clearance	1	40	40
Total Cost			\$4696.23

10.0 Future Work

In working with the Crum Woods Stewardship Committee and Swarthmore Grounds, a number of other sites within the Crum were identified as candidates for future projects. The first of these are a number of steep sections of trail North of the boardwalk project site. The tread in these sections is quite uneven and eroded with many exposed roots. Images of these sections are shown below in Figure 17. Potential solutions may include the installation of stone or wood check steps with backfill in place of an entire trail reroute.

Another potential project involves the installation of a more permanent structure to replace the small footbridge crossing a culvert in the trail (Fig. 18). This site is located at the Northernmost tip of the Crum Woods trail where it intersects with Plush Mill Road. Ideally, a more substantive boardwalk structure similar to the one shown in this report would be installed at that location, but extensive permitting would be required due to its proximity to Crum Creek.

These two projects are the most attainable of the ones we came across over the course of this project, but some more ambitious projects within the Crum Woods also exist. A large-scale project currently in its infant stages but one that may be amenable to future E90 projects is the proposed removal of the dam below the Strath Haven apartments to aid in the migration of native aquatic life and remove built-up sediment. Initial water quality data measurements could be useful in this long-term project. Also, with the successful submission of the permit needed for

this project as a starting point, we believe that the procurement of a permit to construct a pedestrian bridge across Crum Creek can also be approached.

Furthermore, our small sample of in-lab testing of pressure-treated boards also proved to be quite interesting; future work could test more dimensions, spans, moisture contents, and knot inclusions within pressure-treated lumber in order to see how strength is affected.



Figure 17. Images of eroded section of Valley Walk Trail, south Crum Woods



Figure 18. Image of small footbridge on north side of Crum Woods near Plush Mill Road

11.0 Conclusion

11.1 Engineering Design

The constraints used to govern our design problem were the USFS puncheon specifications in Appendix C, the Trail Construction and Maintenance Notebook, and guidance from Ross Bickhart, P.E. Structural analysis design considerations include ASTM standards, the AASHTO LRFD Guide Specification For The Design of Pedestrian Bridges, and the SPIB Grading Rules and AWC National Design Specification for Southern Yellow Pine. From these constraints, the standard design drawings were developed and approved by Ross Bickhart, P.E.. In addition, the boardwalk construction follows Chapters 102 and 105 of the Pennsylvania Code with permit approval from the PADEP.

11.2 Takeaways

This project expanded our knowledge of design, permitting, and construction - all important skills as we enter careers in environmental engineering and conservation work after graduation. In sum, this project is not only an important exploration into real-world engineering design and construction, but it also directly benefits the Swarthmore community at large with increased utility and sustainability of the Crum Woods trail system. Some key takeaways from this project were the development of engineering design skills, ability to work collaboratively with both community and state stakeholders, and an appreciation for the time commitment required for real-world engineering and construction processes. Additionally, we were able to successfully connect our previous professional experiences in conservation work with our academic experiences within the Swarthmore engineering department.

12.0 Acknowledgements

While Jonah and Emily were the main leaders of this project, it would not have been possible without the help of the Swarthmore Arboretum, the College, and the broader community. We would like to thank and acknowledge the following individuals for their support, generosity, and guidance throughout this project.

Professor Matt Zucker, Advisor

Professor Fiona O'Donnell, Advisor

J. Johnson, Engineering Machine Shop Technician

Jeff Jabco, Swarthmore Director of Grounds

Lars Rasmussen, Swarthmore Arboretum Horticultural Supervisor

Sue MacQueen, Campus Engagement Coordinator

Mike McGraw, RES Senior Wildlife Biologist

Crum Woods Stewardship Committee

Ross Bickhart, P.E., Senior Project Manager, Gilmore & Associates, Inc.

Govind Daryani, DEP Project Manager

David Caplan, Biologist, USACE

Emily Ashberry, Aquatic Biologist PADEP

Joshua Hassler, Biologist PADEP

And all the friends, family, staff, and others who have supported us along the way!

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14.0 Appendices

A) PADEP Pre-Application Meeting Notes

February 2, 2023

10:00-10:30 am

PADEP Pre-application Meeting Notes

Project: Boardwalk for Swarthmore Senior Engineering Capstone

Attendees:

Govind Daryani (DEP Project Manager)
David Caplan (Biologist, USACE)
Emily Ashberry (Aquatic Biologist PADEP)
Joshua Hassler (Biologist PADEP)
Jonah Ring (Swarthmore College Engineering student)
Emily van Assendelft (Swarthmore College Engineering student)
Jeff Jabco (Scott Arboretum Director of Grounds)
Fiona O'Donnell (Swarthmore College Professor of Engineering)

Overview of Project:

- Swarthmore College Engineering capstone design project
- Installation of ~67' boardwalk/puncheon structure on chronically flooded section of trail
- Materials: Treated ground-contact timber, timber lok fasteners, steel rebar

Questions from DEP:

Is there wetland in the project site?

- No wetland impact is anticipated: minimal excavation for sill installation, no backfill will be utilized

How far apart are the supports?

- We will be installing approximately 14 mud sills at alternating intervals of 6' and 3' over the length of the identified trail section

What is the drainage area of the site?

- The site is located within the floodplain of the Crum Creek as the main stream

Overall project area identified

- Where you're going to be putting materials, accessing for construction
- Need to develop a plan of limits of disturbance: where we are putting materials, how we are accessing site

Will this impact the creek at all?

- No placement of rock, gravel, concrete is anticipated
- USACE representatives stated under Section 404 of The Clean Water Act: if not doing any filling, then technically USACE does not have any authority over the project. Only has authority if utilizing fill materials that impact the wetland or waterway. (USACE Comment: More specifically, no authority unless the work involves the discharge of

dredged and/or fill materials in Waters of the United States including certain waters and wetlands).

PNDI Impacts:

- DCNR: Threatened or endangered plants in the area - southern red oak (*quercus falcata*).
- Correspondence with DCNR - as long as not doing any tree cutting, no impact anticipated
- Per Jeff Jabco: Southern red oak tree is not in flood plain, it is high up on the adjacent hill.
- Fish and Boat Commission - species not displayed on report, must correspond with them and obtain clearance
- Must obtain clearances from both agencies before submission of DEP permit

Permit Type

- Existing trails and access roads are allowed by GP-7, this is a FEMA floodplain so we will apply for GP-11 for rehabilitation/maintenance of an existing facility.
- Will need to obtain an engineer certification to certify design is safe for public use (we will contact the certified civil engineer associated with the college, Ross Bickhart)
- Will also need to submit a paragraph explaining how the project will have no impact on the adjacent floodway/waterway
- What is the general timeline for the permit once it is submitted? 10 days for prelim review + 93 days for processing - maximum timeline
- PADEP representative stated that they will attach the Pennsylvania State Programmatic General Permit #6 (PA SPGP-6 – USACE permit type) with their State permit to Federally authorize incidental discharges into a creek or wetland.

Next Steps:

- Obtain final PNDI Clearances (DCNR, Fish and Boat Commission)
- GP-11 Permit
 - Waterway non-impact statement
 - Engineer Certification
 - Other permit-specific requirements (i.e. detailed site map including limit of disturbance, project description, site-specific drawings/plans, etc.)
 - Site inspection for wetlands within the limit of disturbance

B) GP-11 Permit Documentation (GP112301223-009)

March 15, 2023

Pennsylvania Department of Environmental Protection
Southeast Regional Office
2 East Main Street
Norristown, PA 194001
Attn: Ms. Ranjana Chopra Sharp, Civil Engineer Manager

(VIA EMAIL)

Crum Woods Boardwalk

Dear Ms. Sharp:

This project proposes to build a boardwalk on a section of the Crum Woods trails adjacent to Swarthmore College. The purpose of this project is to improve trail sustainability and prevent erosion in an area that commonly floods and becomes too muddy to access. This task requires the use of General Permit 11 (GP-11).

The timeline on this project is limited to the end of the spring semester (April 28), so we request this application be expedited.

Please find attached the General Permit Registration form with applicable supporting documents. A scan of the check for application fees is attached, and the physical check will be mailed to your attention along with a copy of this cover letter.

Please let me know if you have any questions or need additional information.

Sincerely,
Emily van Assendelft and Jonah Ring
Senior Engineering Students at Swarthmore College

cc: Jeff Jabco, Swarthmore College Director of Grounds



**CHAPTER 105 WATER OBSTRUCTIONS AND ENCROACHMENT
GENERAL PERMIT REGISTRATION**

SECTION A. APPLICANT INFORMATION						
<input type="checkbox"/> FERC Natural Gas Activity		Docket Number _____		Type of Facility _____		
Has a Water Quality Certification (WQC) request been sent to DEP? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No						
<input type="checkbox"/> Activity Subject to FERC approval and/or Oil & Gas Exploration, Production, Storage or Transmission if the activity is regulated by FERC and provide the FERC docket number.						
Applicant's Name / Client Swarthmore College		DEP Client ID# (if known)		Employer D# (EIN) 231352683		
Client Information - Please select Client Type / Code from drop down box under the correct entity shown below. (or may be written in) ↓						
Government		Non-Government		Individual		
n/a non-applicable		OTHER Other(Non-Govt)		OTHER Other(Non-Govt)		
Mailing Address Swarthmore College, 500 College ave.		City Swarthmore		State Pa	ZIP + 4 19081-1390	
Contact Person - Last Name Ring		First Jonah	MI D	Suffix	Telephone (818) 823-1193	
Email Address jring1@swarthmore.edu						
SECTION B. CONSULTANT INFORMATION (If applicable) <input checked="" type="checkbox"/> N/A						
Contact Person - Last Name		First	MI	Suffix	Consultants Title	Consulting Firm
Mailing Address		City		State	ZIP + 4	
Telephone ()		Fax ()		Employer ID# (EIN)		
Email						
SECTION C. PROJECT INFORMATION						
Project / Site Name Crum Woods Boardwalk			DEP Site ID# (if known or leave blank)			
Client Relationship - Please select Site-to-Client Relationship / Code from drop down box to the right. (or may be written in) →			Double-click on shaded area below to select correct Site-to-Client Relationship / Code ↓ Students at Swarthmore College			
County Delaware	Municipality <input type="checkbox"/> City <input checked="" type="checkbox"/> Borough <input type="checkbox"/> Township		Note: Municipal & County Notification is Required			
Site Location / Address <small>adjacent to Crum Creek near Yale ave. and Strath Haven apartments</small>		City Swarthmore		State Pa	ZIP + 4 19081-1390	
Collection Method: <input type="checkbox"/> EMAP <input type="checkbox"/> HGIS <input type="checkbox"/> GISDR* <input type="checkbox"/> ITPMP <input checked="" type="checkbox"/> GPS <input type="checkbox"/> WAAS <input type="checkbox"/> LORAN						
Check the horizontal reference datum (or projection datum) employed in the collection method.						
EMAP and HGIS (PNDI) have known datum and do not require checking here. <input type="checkbox"/> NAD27 <input type="checkbox"/> NAD83 <input checked="" type="checkbox"/> WGS84						
(GEO84) LAT.: 39.8965776		LONG.: -75.3560511				

NOTE: A Submerged Lands License Agreement (SLLA) with an annual fee, if applicable, may also be required for your project. You will be notified if an SLLA is required.

The Aquatic Resources Impact Table (SECTION E. PROPOSED IMPACTS) must be completed or equivalent submitted for this registration to be complete.

SECTION D. REGISTRATION CHECKLIST AND REQUIREMENTS

Please place an "X" next to each item (1-9) to ensure it is completed and/or provided.

Unless otherwise specified, all items are **required** to ensure a complete Registration package.

Provide ONE (1) ORIGINAL and ONE (1) COPY of the Registration package

Please provide a copy of the Registration form to the Municipality & County in which the work will be performed. Proof of receipt is not required to be provided to DEP.

1. REGISTERING A GENERAL PERMIT (GP) check all that apply

Federal, State, county or municipal agencies or municipal authorities:

EXEMPT from fees

<input type="checkbox"/>	GP-1	Fish Habitat Enhancement Structures	Per Project	\$ 50	= \$ _____
<input type="checkbox"/>	GP-2	Small Docks and Boat Launching Ramps.....	Per Dock / Ramp _____ (#) x	\$ 175	= \$ _____
<input type="checkbox"/>	GP-3	Bank Rehabilitation, Bank Protection and Gravel Bar Removal	Per Project _____ (#) x	\$ 250	= \$ _____
<input type="checkbox"/>	GP-4	Intake and Outfall Structures	Per Structure _____ (#) x	\$ 200	= \$ _____
<input type="checkbox"/>	GP-5	Utility Line Stream Crossings	Per Individual Utility _____ (#) x _____ (#) x	\$ 250	= \$ _____
<input type="checkbox"/>	GP-6	Agricultural Crossings and Ramps	Per Crossing / Ramp _____ (#) x	\$ 50	= \$ _____
<input type="checkbox"/>	GP-7	Minor Road Crossings ²	Per Crossing _____ (#) x	\$ 350	= \$ _____
<input type="checkbox"/>	GP-8	Temporary Road Crossings ²	Per Crossing _____ (#) x	\$ 175	= \$ _____
<input type="checkbox"/>	GP-9	Agricultural Activities.....	Per Project	\$ 50	= \$ _____
<input type="checkbox"/>	GP-10	Abandoned Mine Reclamation.....	Per Project	\$ 500	= \$ _____
<input checked="" type="checkbox"/>	GP-11	Maintenance, Testing, Repair, Rehabilitation, or Replacement of Water Obstructions and Encroachments ¹		\$ 750	+
<input type="checkbox"/>		Temporary Disturbance (\$400/0.1ac)	_____ acres x \$4,000 =	\$ _____	+
<input checked="" type="checkbox"/>		Permanent Disturbance (\$800/0.1ac)	0.01 acres x \$8,000 =	\$ <u>80</u>	= \$ <u>830</u>
<input type="checkbox"/>	GP-15	Private Residential Construction in Wetlands ¹		\$ 750	+
<input type="checkbox"/>		Temporary Disturbance (\$400/0.1ac)	_____ acres x \$4,000 =	\$ _____	+
<input type="checkbox"/>		Permanent Disturbance (\$800/0.1ac)	_____ acres x \$8,000 =	\$ _____	= \$ _____

GP(s) FEE subtotal (b) \$ 830

	Applicant Entry	DEP Use Only
2. Location Map (USGS quad map) with project site marked:	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3. Color Photographs with dates, locations, and descriptions: <input type="checkbox"/> GP-3 <input checked="" type="checkbox"/> GP-11 <input type="checkbox"/> N/A	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4. Project Description: (Example: Linear pipeline project using multiple GP-5's and GP-8's; One GP-7 for an access road to my property) Senior engineering design project uses one GP-11 for the installation of a boardwalk on a chronically flooded section of trail in Swarthmore College's Crum Woods. The boardwalk sills will be set 6-8 inches below the surface of the existing trail and anchored with rebar, no backfill will be employed in the construction of the boardwalk structure.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5. Site Specific and/or Standard Drawings are (required for all) project's GP activities. For Activities that qualify for GP-7 or GP-11 Plans, specifications, and reports for bridges and culverts across a stream which are to be used by the general public such as an access to an industrial, commercial or residential development, etc., shall be prepared by a registered professional engineer and shall be affixed with their seal and certification which shall read as follows on the drawings: If the project includes a bridge or culvert replacement or the proposed work will change the waterway opening, please complete and provide the <u>Bridge and/or Culvert Replacement Projects or Projects That Change the Waterway Opening (3150-PM-BWEW0552B)</u> worksheet. If the project consists of similar work (replacement or change in waterway opening) on more than one structure, provide the data requested for each structure included in this Registration package. <i>"I (name) do hereby certify pursuant to the penalties of 18 Pa. C.S.A. Sec. 4904 to the best of my knowledge, information and belief, that the information contained in the accompanying plans, specifications, and reports has been prepared in accordance with accepted engineering practice, is true and correct, and is in conformance with Chapter 105 of the rules and regulations of the Department of Environmental Protection."</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
6. Proposed Project Purpose depicting the site of the projects GP activities and impacts. Briefly discuss the need for the authorization.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
7. Erosion & Sediment Control Plan (E&S Plan) (Required for all GP's but specifically required with submission with a registration of GP-11 or GP's for oil and gas related activities submitted to DEP.)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
8. Pennsylvania Natural Diversity Inventory (PNDI): PNDI Search Receipt and clearance letters, if available. See additional requirements for submission with Avoidance Measures and/or Potential Impacts.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
9. Activities which impact wetlands: (For State Regulated Impacts) Please place an "X" next to the appropriate box indicating the information provided: <ul style="list-style-type: none"> ➤ N/A because no wetland impacts are proposed or no compensatory mitigation is necessary. <input checked="" type="checkbox"/> ➤ A wetland delineation with complete data sheets in accordance with the 1987 Corps of Engineers Wetland Delineation Manual AND the appropriate Regional Supplements to the Corps of Engineers Wetland Delineation Manual for use in Pennsylvania..... <input type="checkbox"/> ➤ If direct or indirect wetland impacts are greater than 0.05 acre, a compensatory mitigation plan in accordance with the Department's Replacement criteria which provides compensation for both affected acreage, and functions at a minimum of one to one ratio. <input type="checkbox"/> ➤ If compensatory mitigation onsite is determined not feasible: A check, number _____, in the amount of \$ _____ payable to the National Fish and Wildlife Foundation, N.A. 1237, as compensatory mitigation for ___ acres of impact in wetlands, in accordance with the Pennsylvania Wetland Replacement Project..... <input type="checkbox"/> <p style="text-align: center;">(Additional Mitigation May Be Required by U.S. Army Corps)</p>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
NOTE: If the Pennsylvania Wetland Replacement Fund is proposed to be used as compensatory mitigation for waters of the Commonwealth the U.S. Army Corps of Engineers may also require additional mitigation if the proposed activity impacts waters of the United States.		



Applicant's Name / Client Jonah Ring

AQUATIC RESOURCE IMPACT TABLE
FOR PENNSYLVANIA CHAPTER 105 WATER OBSTRUCTION AND ENCROACHMENT APPLICATION / REGISTRATION

DEP USE ONLY		Project Information					PA DEP / 105						Enter Only If Different from DEP Impacts Army Corps Impacts:	
PADEP Permit Number	Structure / Activity unique identifier	Aquatic Resource Type	Latitude dd nad83	Longitude dd nad83	Waters Name	PA Code Chapter 93 Designation	Work Proposed	DEP Impact Type temp / perm	ACOE Impact Type temp / perm	Watercourse Impact Top of Bank to Top of Bank	Floodway Impact Top of Bank Landward	Wetland Impact Dimensions	Watercourse Impact	Wetland Impact
										Length and Width in feet	Length and Width in feet	Length and Width in feet	Length and Width in feet	Length and Width in feet
	GP-11	Perennial	39.896577	-75.3560511	Crum Creek	WWF	Excavation	Perm	Temp	n/a -	72 - 6	n/a -	-	-
										-	-	-	-	-
										-	-	-	-	-
										-	-	-	-	-
										-	-	-	-	-
										-	-	-	-	-
										-	-	-	-	-

PADEP Impact Type: temporary or permanent.

Permanent Impacts are those areas affected by a water obstruction or encroachment that consist of both direct and indirect impacts that result from the placement or construction of a water obstruction or encroachment and include areas necessary for the operation and maintenance of the water obstruction or encroachment located in, along or across, or projecting into a watercourse, floodway or body of water.

Temporary Impacts are those areas affected during the construction of a water obstruction or encroachment that consists of both direct and indirect impacts located in, along or across, or projecting into a watercourse, floodway or body of water that are restored upon completion of construction. This does not include areas that will be maintained as a result of the operation and maintenance of the water obstruction or encroachment located in, along or across, or projecting into a watercourse, floodway or body of water (these are considered permanent impacts).

SECTION F. CERTIFICATION

I certify under penalty of law that the information provided in this permit registration is true and correct to the best of my knowledge and information and that I possess the authority to undertake the proposed action. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations. (If any of the information and/or plans is found to be in error, falsified, and/or incomplete, this authorization/verification may be subject to modification, suspension, or revocation in accordance with applicable regulations.) I further certify that this project complies with all the conditions of the general permit.

Jeffrey P. Jabeo
Signature of Applicant / Owner

3/16/23
Date

Jeffrey P. Jabeo
Typed / Printed Name

Director of Grounds/Swarthmore College
Typed / Printed Title

This General Permit shall not be effective until the owner has had their E&S Plan reviewed by the appropriate Regional Office or District, and, where required, obtained an SLLA from DEP.

THIS ACKNOWLEDGED COPY OF THIS GENERAL PERMIT REGISTRATION PACKAGE AND THE E&S PLAN MUST BE AVAILABLE AT THE PROJECT SITE DURING CONSTRUCTION.

SECTION G. DECISION / DISPOSITION – COMPLETED BY DEP

Decision Review:

Shabnam Dhull

DEP / District Reviewer Signature

GP 112301223-009

SHABNAM DHULL

Reviewer's Typed / Printed Name

GP

NOTE: See Aquatic Resource Impact Table for any additional authorizations.

Disposition Status

Comments

- ACKNOWLEDGED** Date 04/10/2023
- SLLA Required Yes Attached No
- INCOMPLETE / DEFICIENCY** Date _____
- EXTENSION REQUEST** Date _____
- WITHDRAWN** Date _____

NOTE: If the GP registration information is incomplete a copy of this registration form and requested additional information will be sent to the applicant. A copy of the returned registration form and additional information must be re-submitted within 60 calendar days unless extended by the extension date listed above.

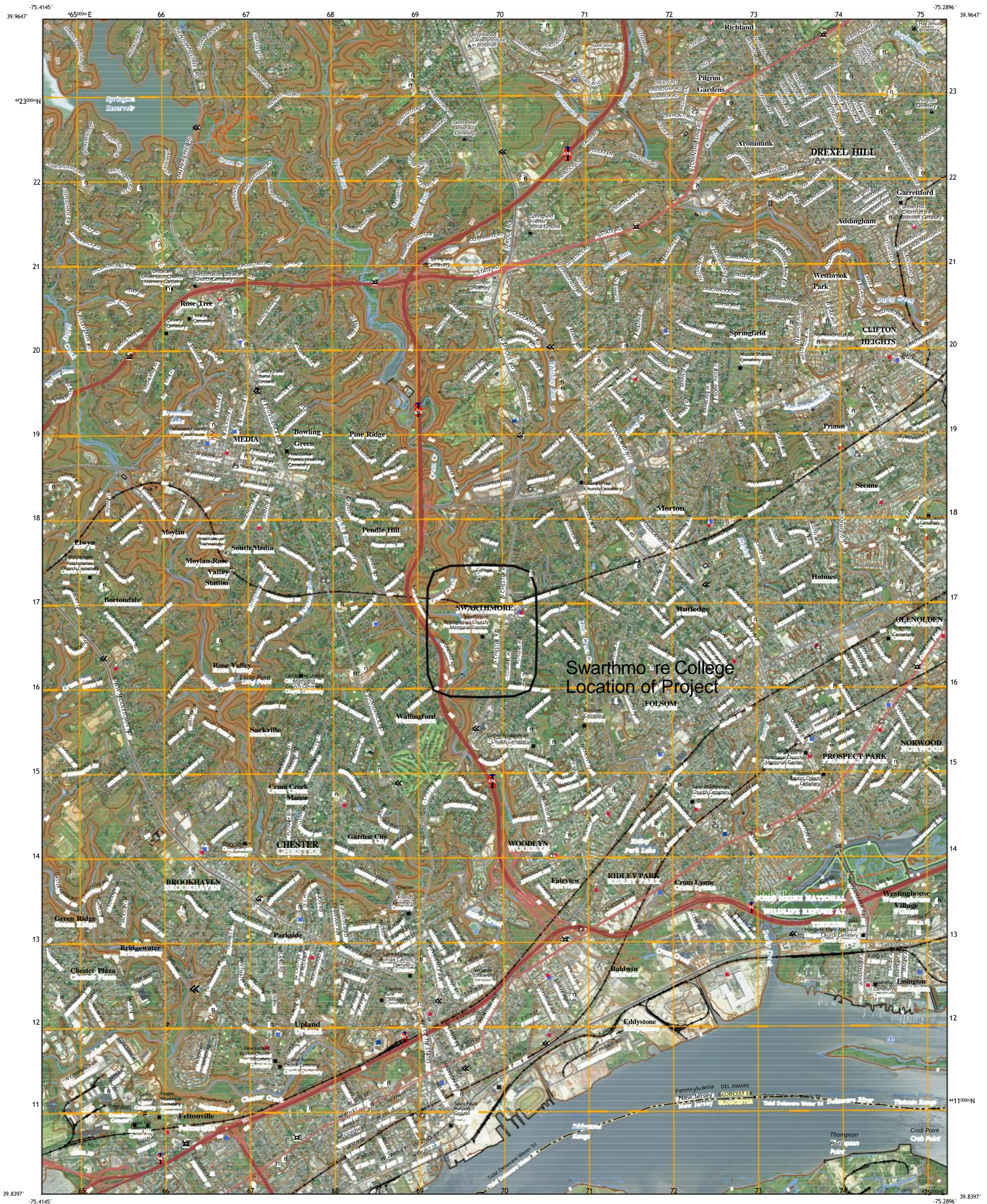
FEDERAL AUTHORIZATION

- Non-reporting PASPGP verification / authorization attached.
- Reporting – A copy of this General Permit registration package has been sent to the U.S. Army Corps of Engineers. Separate federal authorization may be required

NOTE: Please be advised that if the reporting box is checked you do not have Federal authorization for this project and such authorization may be required prior to starting your project. In accordance with Section 404 of the Clean Water Act, a Department of the Army authorization is required for the discharge of dredged and/or fill material into waters of the United States, including jurisdictional wetlands. Section 10 of the Rivers and Harbors Act also requires Department of the Army authorization for any work in, over, or under a navigable water of the United States. In accordance with procedures established with the U.S. Army Corps of Engineers, you will be contacted directly by the Corps regarding Federal Authorization.

SECTION 2

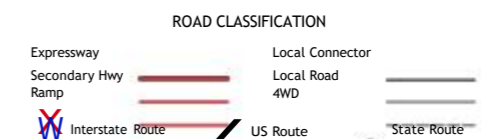
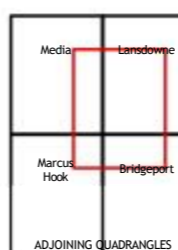
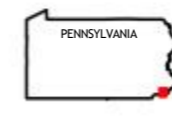
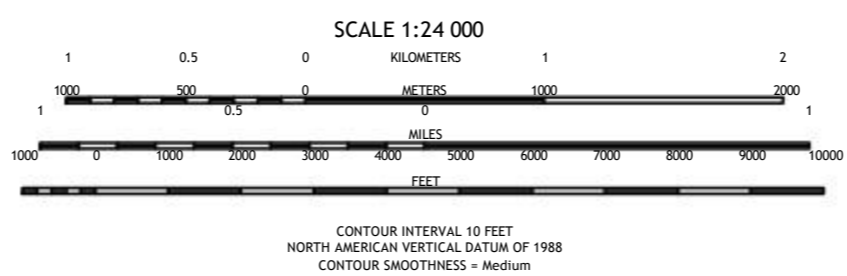
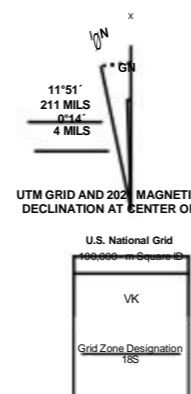
LOCATION MAP



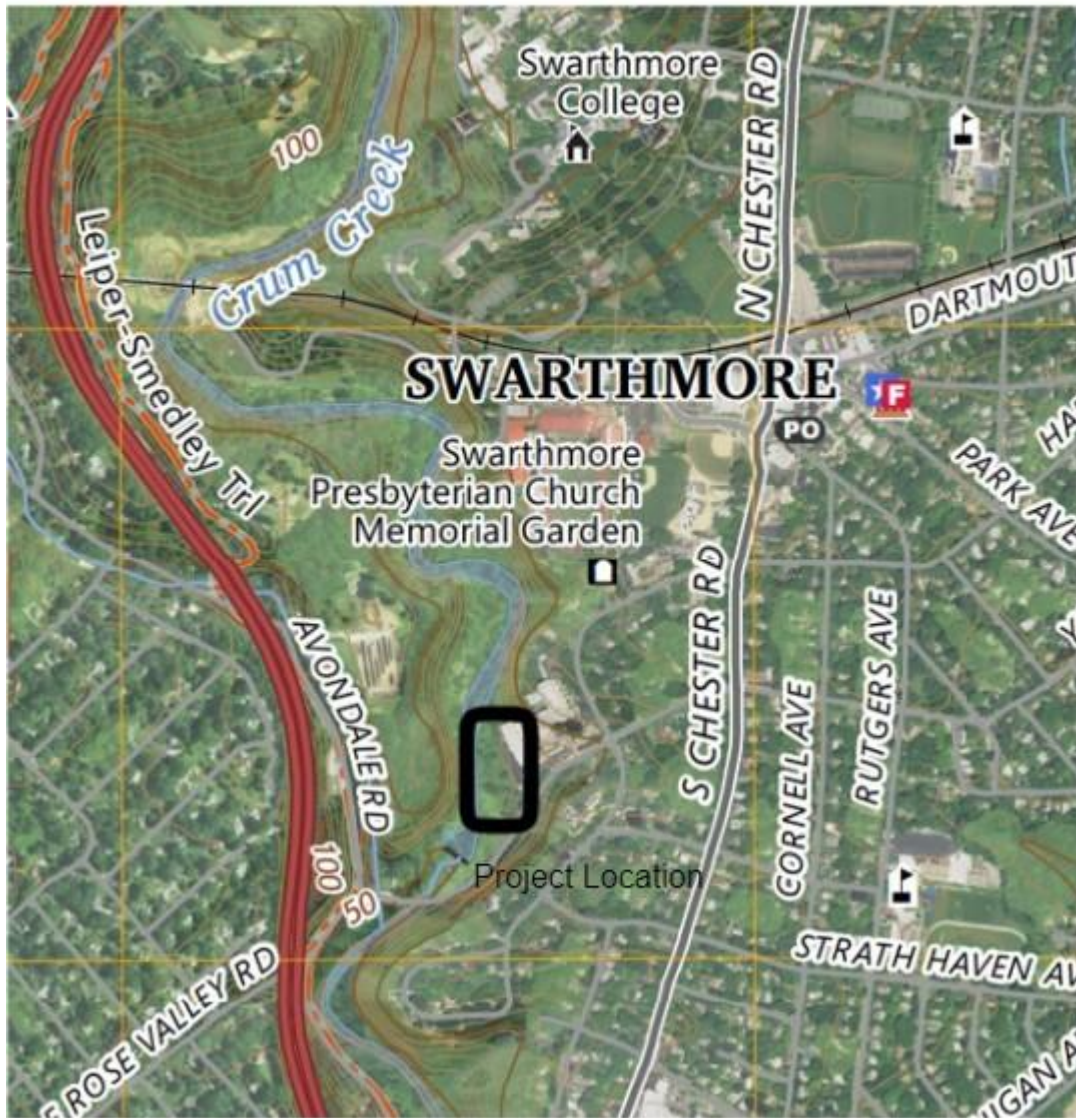
Produced by the United States Geological Survey North American Datum of 1983 (NAD83) Projection and World Geodetic System of 1984 (WGS84) Projection and 1000-meter grid: Universal Transverse Mercator, Zone 18S Data is provided by The National Map (TNM), is the best available at the time of map generation, and includes data content from supporting themes of Elevation, Hydrography, Geographic Names, Boundaries, Transportation, Structures, Land Cover, and Orthoregistry. Refer to associated Federal Geographic Data Committee (FGDC) Metadata for additional source data information.

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands. Temporal changes may have occurred since these data were collected and some data may no longer represent actual surface conditions.

Learn About The National Map: <https://nationalmap.gov>



7.5 Quad Map - Zoom View
Swarthmore College
Location of Project



Crum Woods Trail Map



Alligator Rock
The bedrock of the area is primarily comprised of schist and gneiss. Because schist is a softer stone than gneiss, it is more prone to erosion. As it erodes, it leaves behind dramatic outcroppings of gneiss, such as Alligator Rock.



Leiper-Smedley Trail
The 2.2 mile (3.5 kilometer) paved Smedley-Leiper Trail is currently the only open trail on the west side of the creek.



Crum Meadow
This 6-acre area is commonly known as Crumbenger as a result of the large decorative stones that were placed in the meadow in the late 1980s. It was previously called "Palmer's Meadow" in honor of Samuel Palmer, member of the Class of 1895, Swarthmore professor of botany and early advocate for the founding of the Arboretum.



Crum Creek
Crum Creek runs 22.5 miles, draining a watershed of some 38 square miles. The creek runs from its headwaters in Malvern, Chester County, to the Delaware River, 4 miles downstream from Swarthmore.



Scott Outdoor Amphitheater
The amphitheater was designed by noted Philadelphia landscape architect Thomas W. Sorey and constructed in 1942. Soaring tulip trees and white oaks provide the ceiling for the amphitheater, which is the site of the College's commencement exercises each year.



Wister Garden
This woodland garden is highlighted by sweeps of bulbs and rhododendrons. It was originally the personal garden of the Arboretum's first director, John Wister, and his wife Gertrude Wister, who served as assistant director.

- Leiper-Smedley (2.2 mi) ●●
- Valley Walk (1.7 mi) ●●●
- Crumwalk Path (0.1 mi) ●
- Evans Path (0.1 mi) ●●●
- Bartens Path (0.4 mi) ●●●
- Alligator Step (0.1 mi) ●●●
- Humphry Marshall Path (0.2 mi) ●●●
- Trotter Dell (0.1 mi) ●
- Rhododendron Collection (0.2 mi) ●
- Pierce Path (0.1 mi) ●
- Painter Path (0.1 mi) ●●●
- Sargent Road (0.3 mi) ●
- Asa Gray Entrance (0.05 mi) ●●
- Wister Garden Walk (0.1 mi) ●



- Easy
- Medium
- Challenging
- Seasonal flooding
- Ongoing research site
- Trail head



Boardwalk location

SECTION 3

COLOR PHOTOGRAPHS



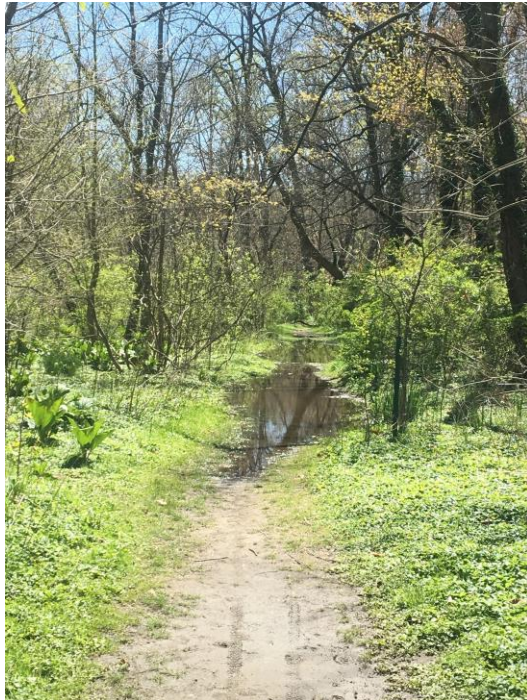
1. Looking South on specified trail section (1/13/23)



2. Looking North on specified trail section (1/13/23)



3. Detail of specified trail section after rainstorm (1/24/23)



4. Looking South on flooded trail section (4/20/22)

SECTION 5

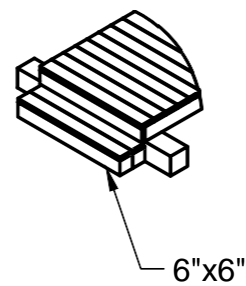
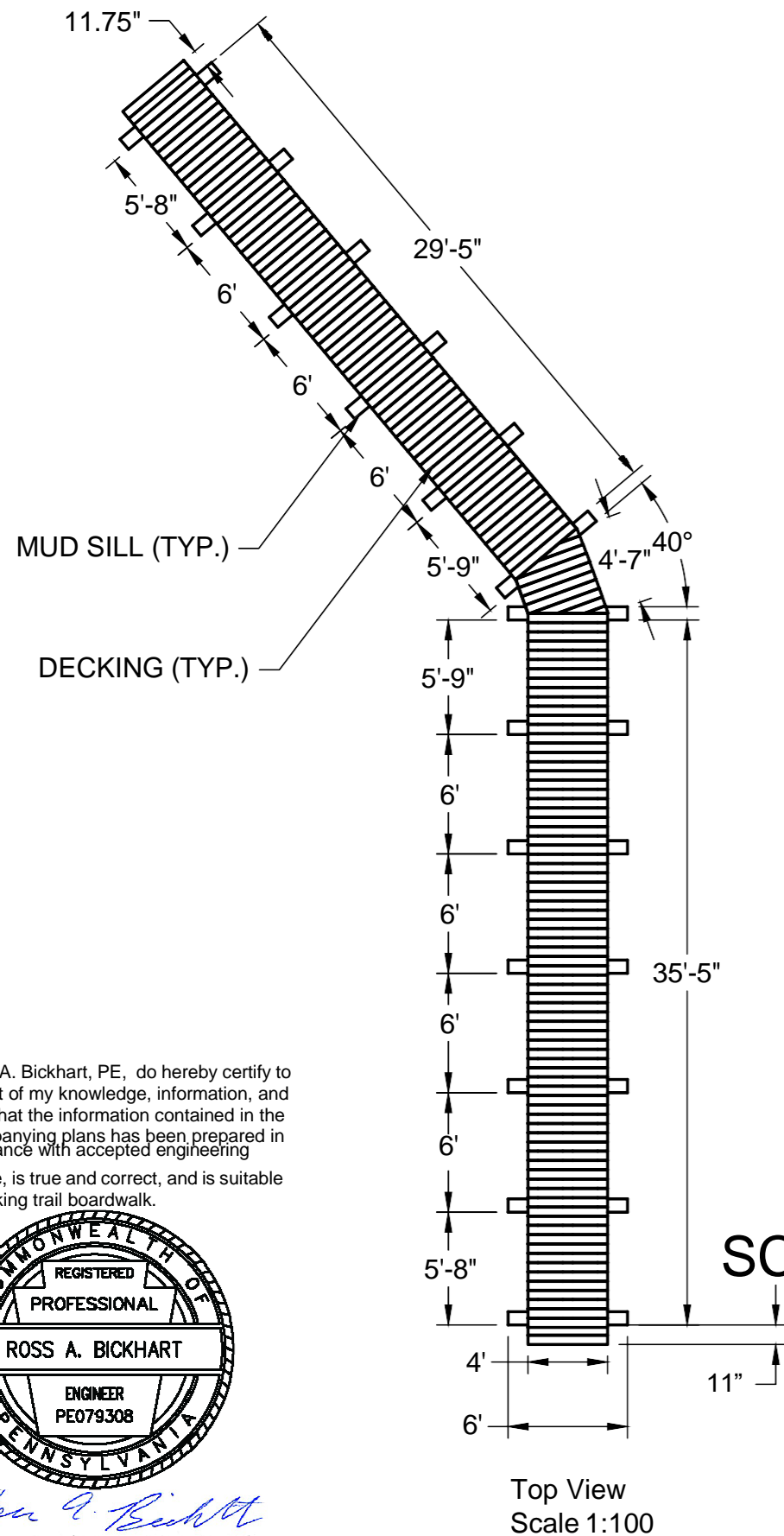
BOARDWALK DRAWINGS

Materials:
 Mud sills are 8"x8" #2 Pressure Treated Timbers at lengths of 6ft
 Stringers are 6"x6" #2 Pressure Treated Timbers at lengths of 6 ft
 Decking is 2"x6" #2 Pressure Treated Boards at 4ft length
 Fastening materials include #4 rebar, 8" length 3/8" dia. galvanized lag screws, and 3-1/2" epoxy-coated wood screws (see Fastening Details)

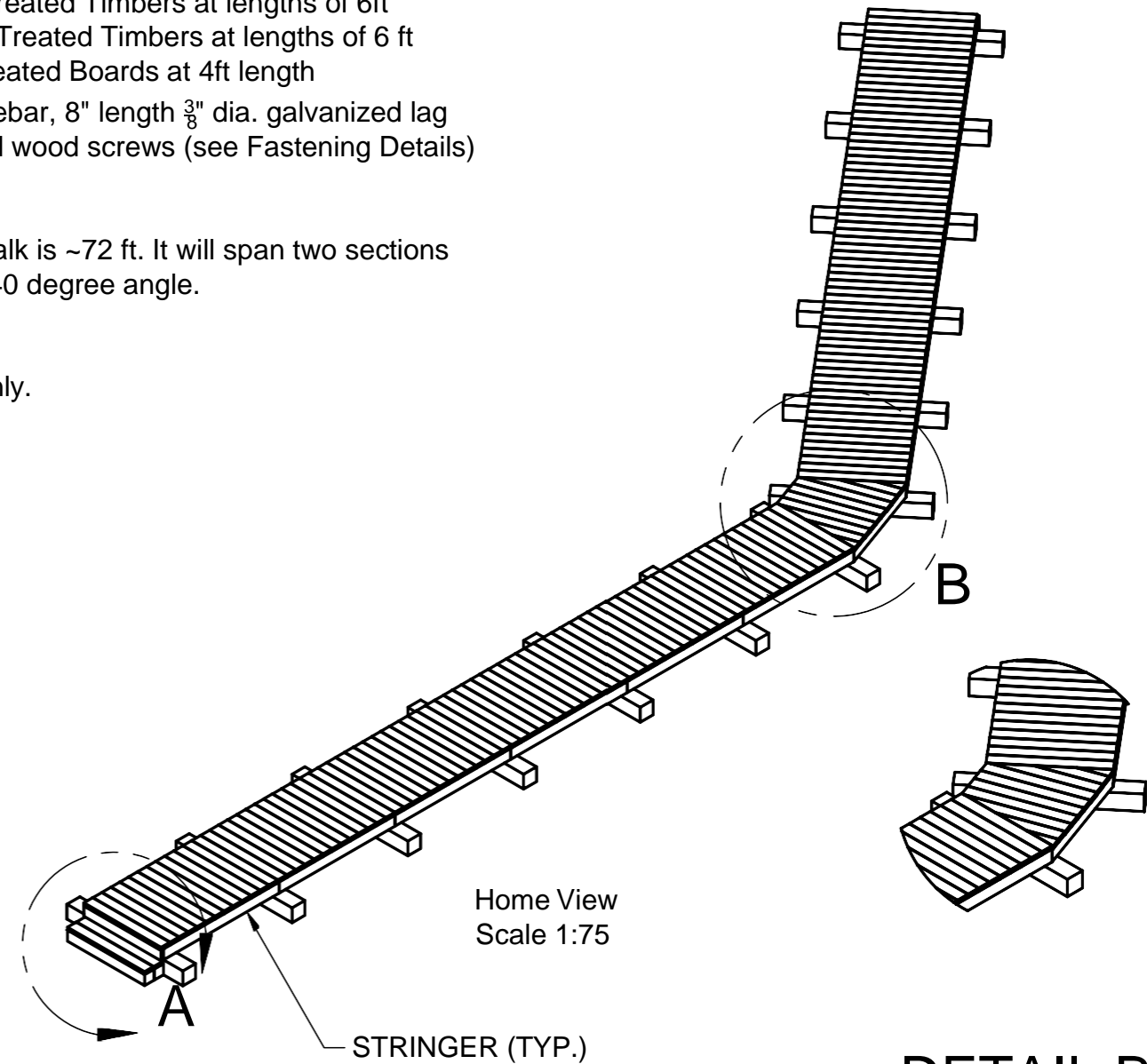
Size:
 The entire length of the board walk is ~72 ft. It will span two sections with one 5' turn that bends at a 40 degree angle.

Constraints:
 Designed for pedestrian loads only.

Detail A: See Step Design
 Detail B: See Turn Design

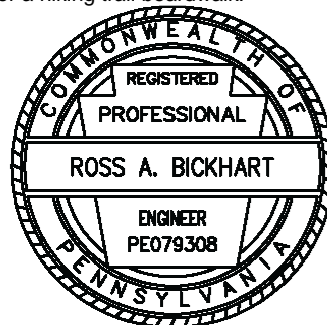


DETAIL A
 SCALE 3/16" = 1'-0"



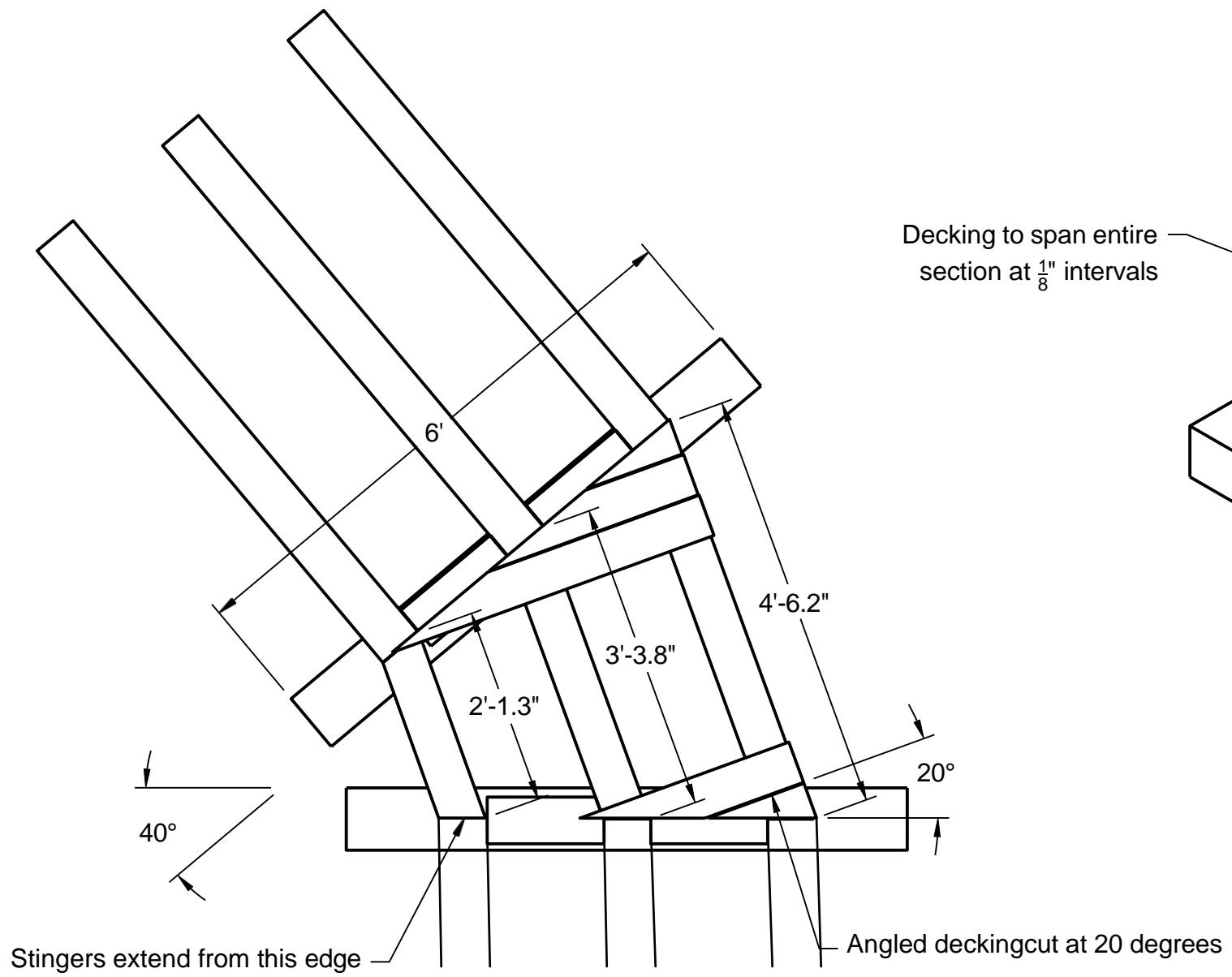
DETAIL B
 SCALE 3/16" = 1'-0"

I, Ross A. Bickhart, PE, do hereby certify to the best of my knowledge, information, and belief, that the information contained in the accompanying plans has been prepared in accordance with accepted engineering practice, is true and correct, and is suitable for a hiking trail boardwalk.

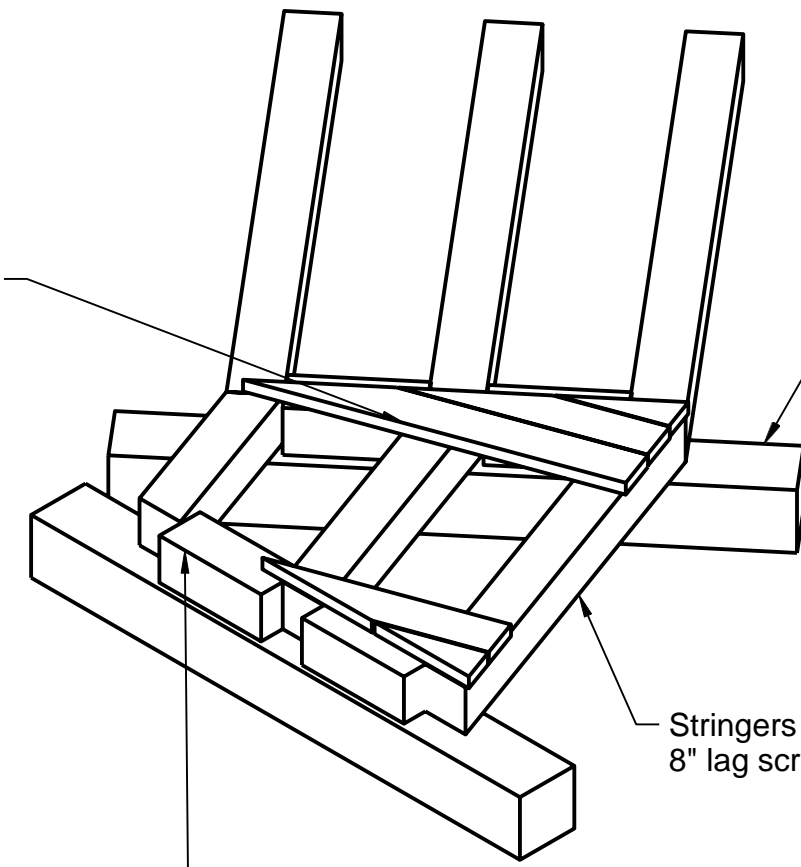


Ross A. Bickhart

PROJECT		E90 Crum Woods Boardwalk		
TITLE		Entire Section		
APPROVED	SIZE	CODE	DWG NO	REV
CHECKED	B			
DRAWN	Emily van Assendelft	2/23/2023	SCALE 1:100	WEIGHT
			SHEET	1/7



Decking to span entire section at $\frac{1}{8}$ " intervals



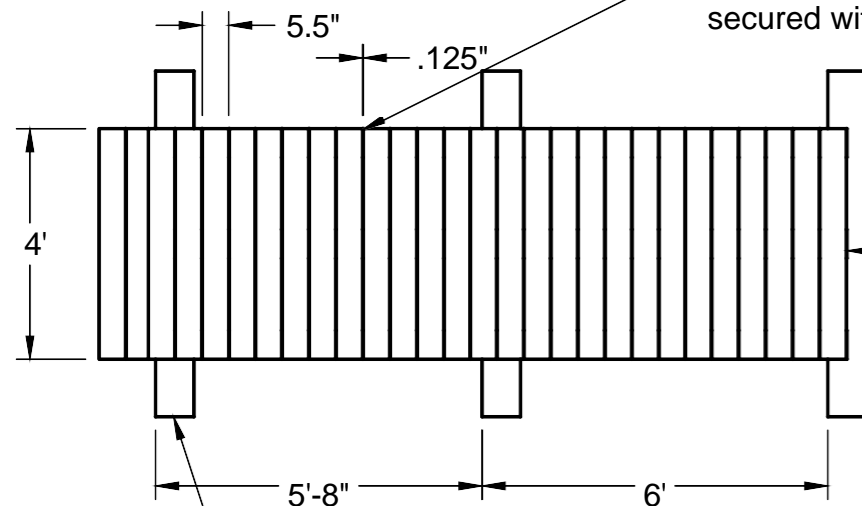
Mud sills secured in ground with #4 rebar
See Figure 15.10 - Puncheon Mudsill anchoring

Stringers secured to mud sill with 8" lag screws with counterbore

In order to secure angled decking, four 6"x6" timbers will be placed to fill the empty space between stringers. 6"x6" timbers will be secured to the mudsills with 8" length $\frac{3}{8}$ " dia. galvanized lag screws. Decking will be secured with 3-1/2" epoxy-coated wood screws to the 6"x6" timbers.

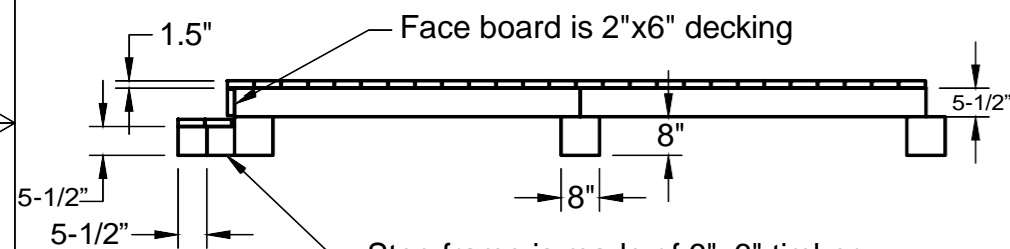
	PROJECT			
	E90 Crum Woods Boardwalk			
	TITLE			
	Turn Detail (w/o decking)			
APPROVED	SIZE	CODE	DWG NO	REV
CHECKED	B			
DRAWN	Emily van Assendelft	2/23/2023	SCALE 1:20	WEIGHT
			SHEET	2/7

4 ft length 2"x6" decking is spaced $\frac{1}{8}$ " apart and secured with wood screws to the stringers

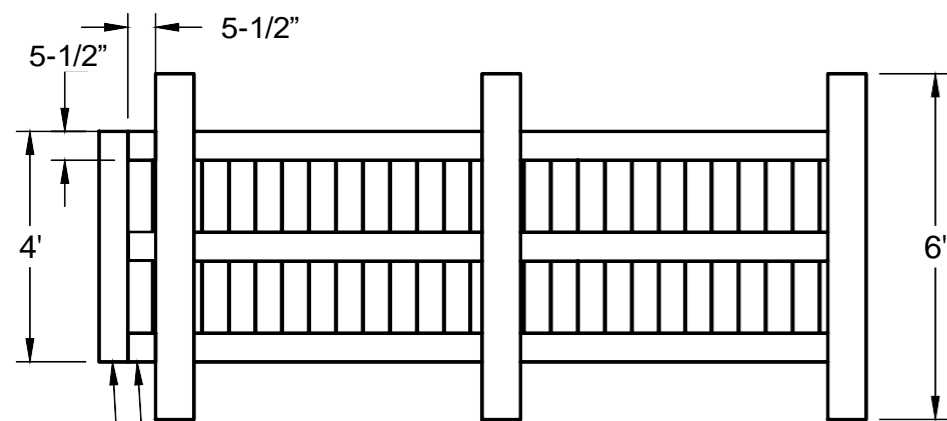


More stringers will be attached here to extend the boardwalk for the entire length of the trail

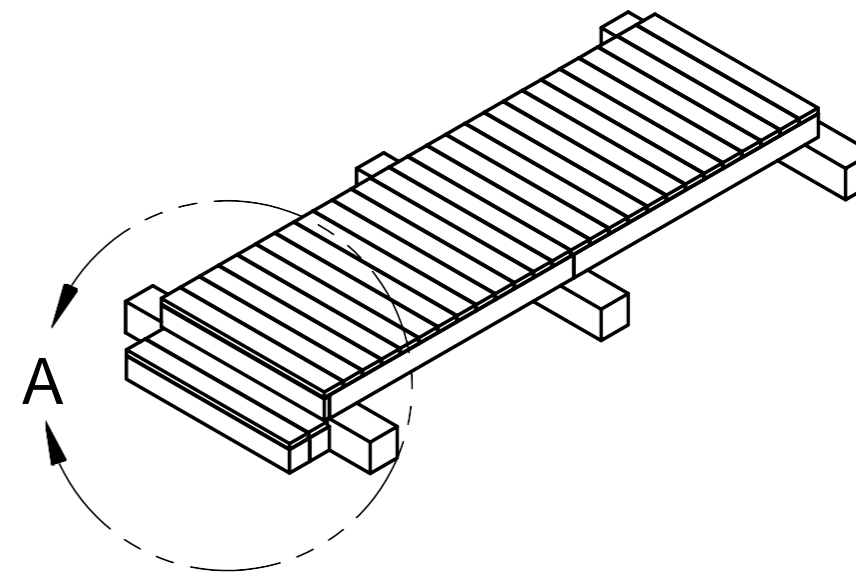
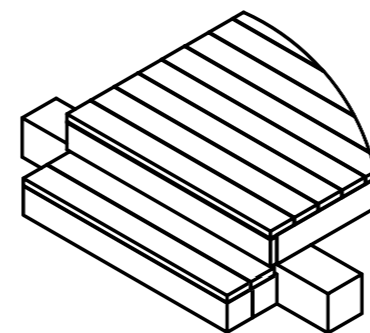
The first set of sills are at 5'-8" to ensure 6' length stringers are flush with the end of the boardwalk



Step frame is made of 6"x6" timber. Inside secured to the mud sill and outside secured to inside with lag screws.



Inside 6"x6" timbers are 6" length (typ. of 3)
Outside 6"x6" timber is 4ft length



Steps will be installed at each end of the boardwalk.

Soil will be dug out to place 6"x6" timbers that are secured to the last mudsill with 8" lag screws and anchored to the ground with 3 ft rebar. See Fastening Details.

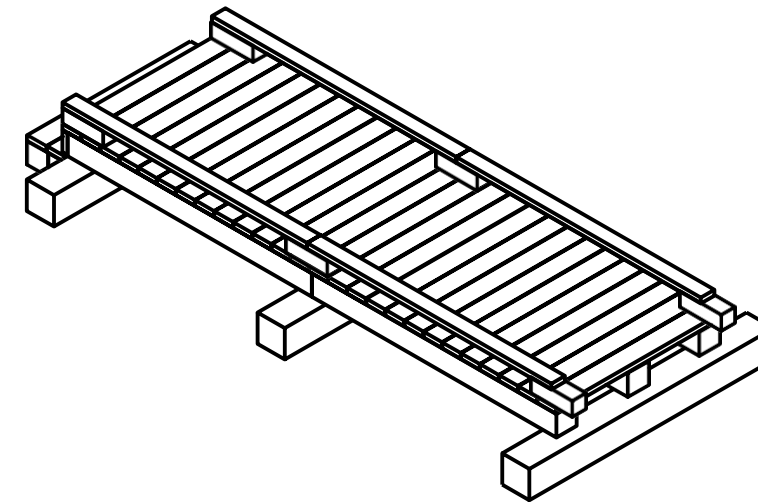
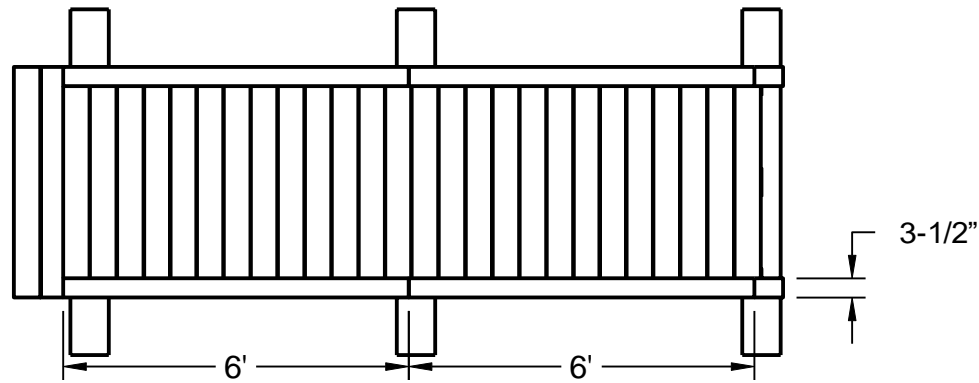
Decking will cover the span of the step and a board will be set vertically to the end of the stringers to cover the front side.

DETAIL A

SCALE $\frac{3}{8}$ " = 1'-0"

		PROJECT		
		E90 Crum Woods Boardwalk		
		TITLE		
		Step Design		
APPROVED	SIZE	CODE	DWG NO	REV
CHECKED	B			
DRAWN	Emily van Assendelft	2/23/2023	SCALE 1:40	WEIGHT
			SHEET	3/7

Curbing will be added to the sides of the boardwalk to keep pedestrians on the boardwalk.
Curbing will not support any load.

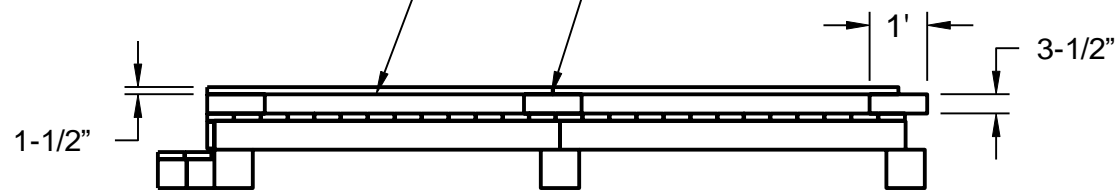


Materials:

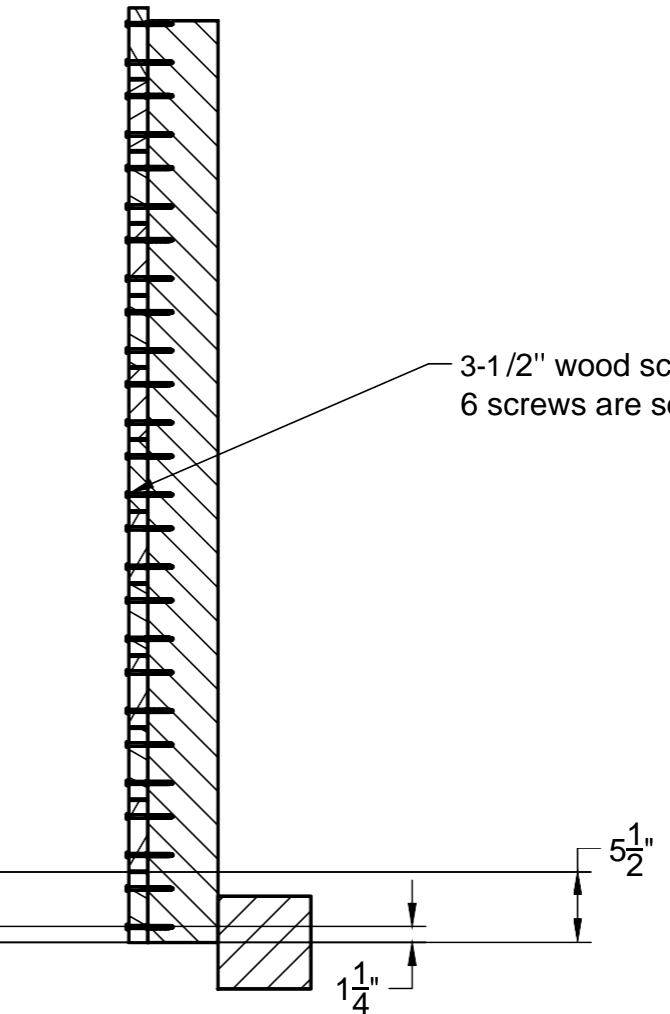
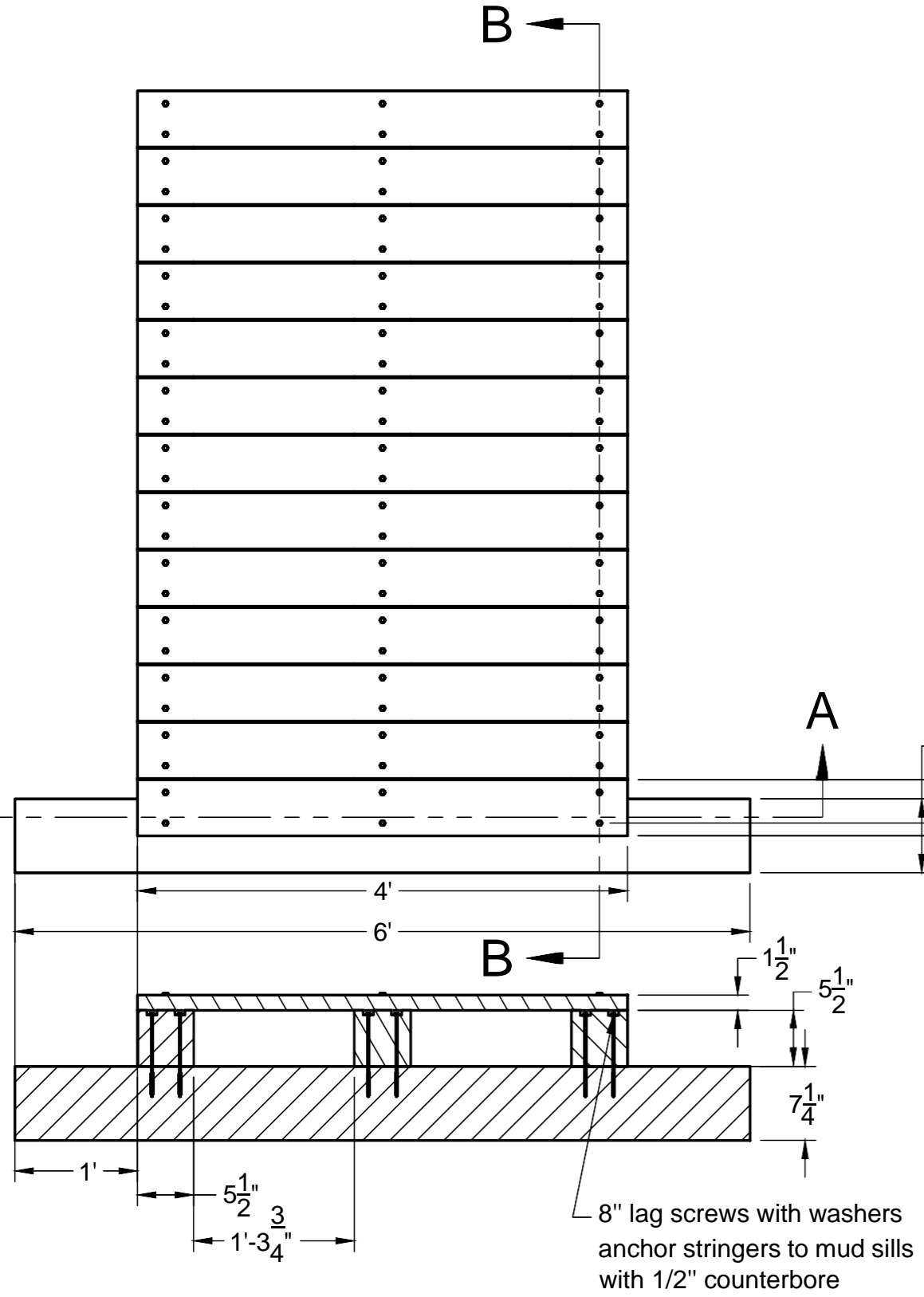
- 2"x4" #2 pressure treated timber at 6 ft lengths
- 4"x4" #2 pressure treated timber at 1 ft lengths
- 3-1/2" and 6" epoxy-coated wood screws

Curbing will be made of 2"x4" boards that span 6 ft.
It will be secured to the spacers with 3-1/2" wood screws.

1ft length 4"x4" spacers will be secured with 6" wood screws

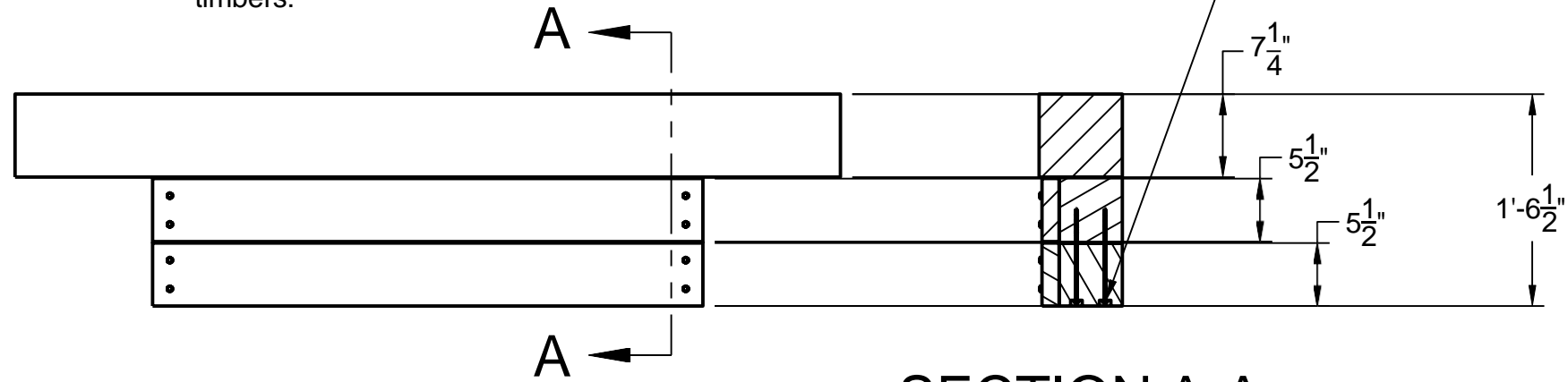


	PROJECT			
	E90 Crum Woods Boardwalk			
	TITLE			
	Extra: Curb Design			
APPROVED	SIZE	CODE	DWG NO	REV
CHECKED	B			
DRAWN	Emily van Assendelft	2/23/2023	SCALE 1:40	WEIGHT
			SHEET	4/7



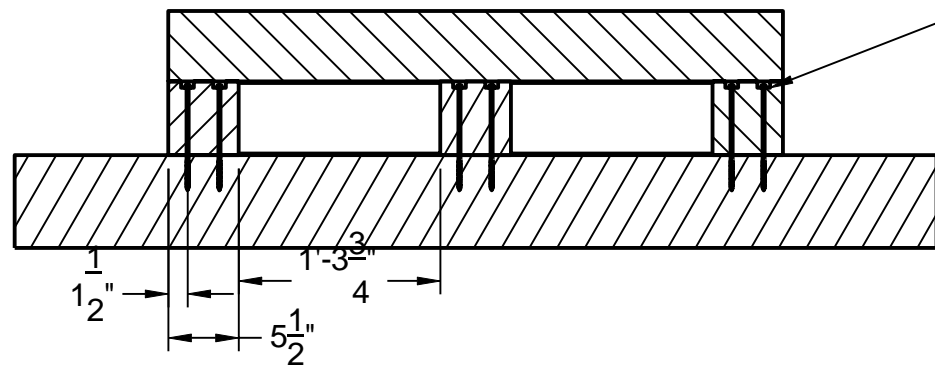
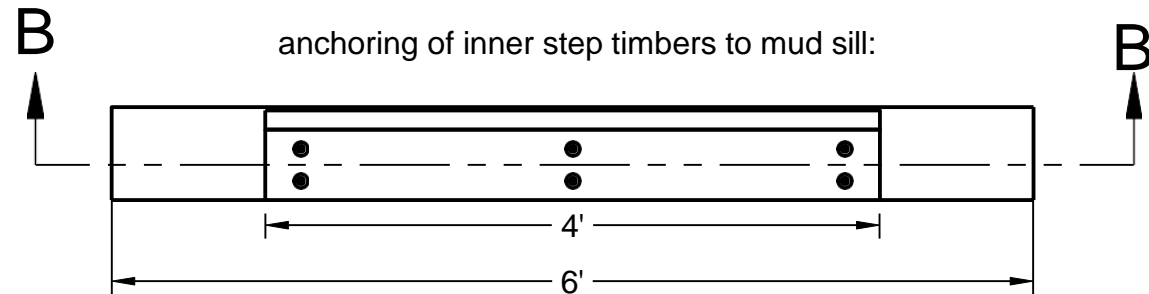
PROJECT			
E90 Crum Woods Boardwalk			
TITLE			
Stringer/Decking Fasteners			
APPROVED	SIZE	CODE	DWG NO
CHECKED	B		
DRAWN	Jonah Ring	2/27/2023	SCALE 1:15
WEIGHT		SHEET 5/7	
REV			

Top view of step and sill; Section A-A shows anchoring of outer step timber to inner step timbers:

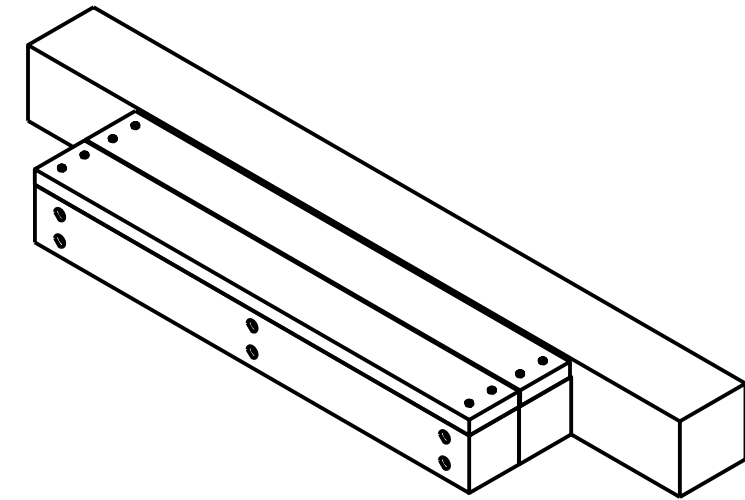


SECTION A-A
SCALE 1:15

Front view of step and sill; Section B-B shows anchoring of inner step timbers to mud sill:



SECTION B-B
SCALE 1:15

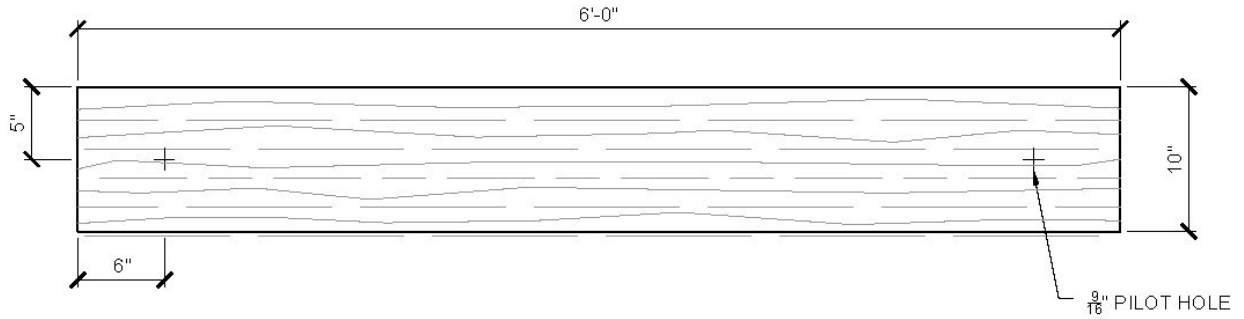


Isometric view of step design; decking secured to top of step with 3-1/2" wood screws

Inner step timbers secured to mud sill with 8" lag screws with a 1/2" counterbore

		PROJECT E90 Crum Woods Boardwalk			
		TITLE Step Fasteners			
APPROVED	SIZE	CODE	DWG NO	REV	
CHECKED	B				
DRAWN	Jonah Ring	2/27/23	SCALE 1:15	WEIGHT	
			SHEET 6/7		

TOP VIEW



SECTION VIEW

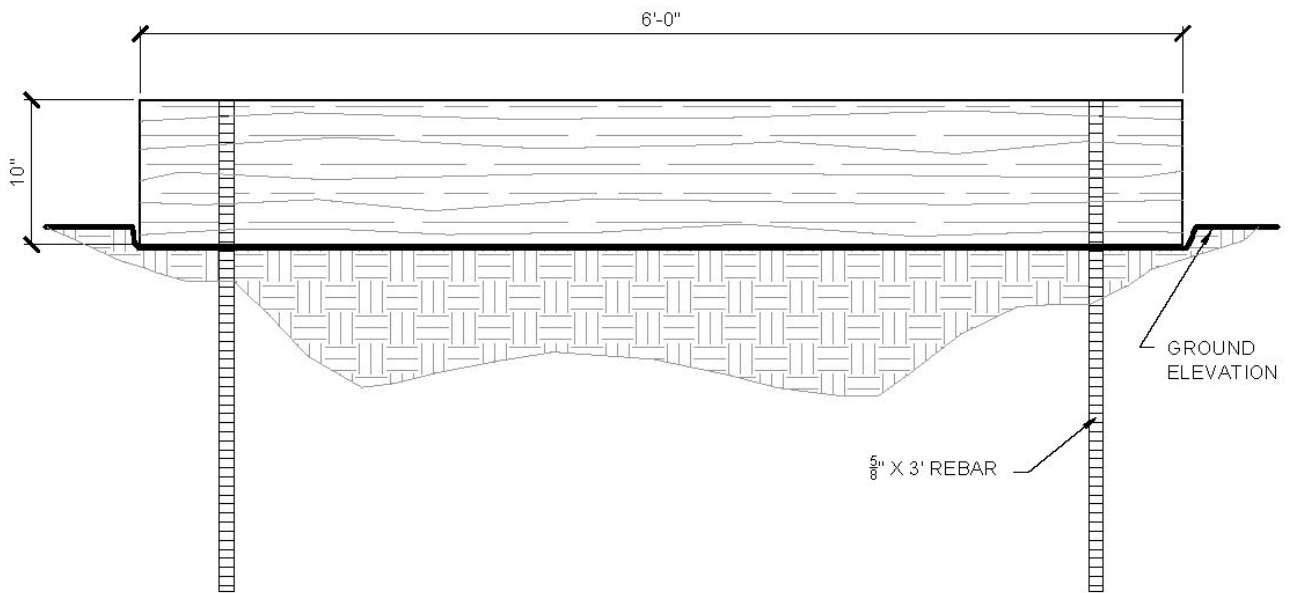


Figure 15.10 - Puncheon Mudsill Anchoing



PUNCHEON MUDSILL ANCHORING

CALIFORNIA STATE PARKS

NOT TO SCALE

SECTION 6

PROJECT PURPOSE NARRATIVE

**Swarthmore College Crum Woods Trails Boardwalk
GP-11 Project Narrative 03/06/2023**

We plan to design and install a boardwalk structure on a section of trail adjacent to Crum Creek within the Crum Woods. The section of trail we have identified is chronically flooded and muddy, forcing walkers to skirt around. This widens the existing trail footprint, decreases trail sustainability, and increases potential for erosion. The installation of a boardwalk over this section of trail will provide a stable and sustainable surface for pedestrians to walk on, increasing the accessibility and longevity of the existing Crum Woods trail system.

The boardwalk structure itself will be approximately 72 feet in length, spanning a section of trail on the Southeast side of the Crum Woods. The structure will be constructed out of #2 pressure treated, ground-contact timber and designed according to existing Forest Service specifications for pedestrian trail boardwalks. The foundation will be composed of thirteen six-foot mud sills set no more than 8 inches below the tread surface and anchored into the ground with rebar. No backfill will be implemented in the design or construction of this boardwalk. Due to the permanent placement of a structure placed within a FEMA AE-designated flood zone, we are seeking a GP-11 permit.

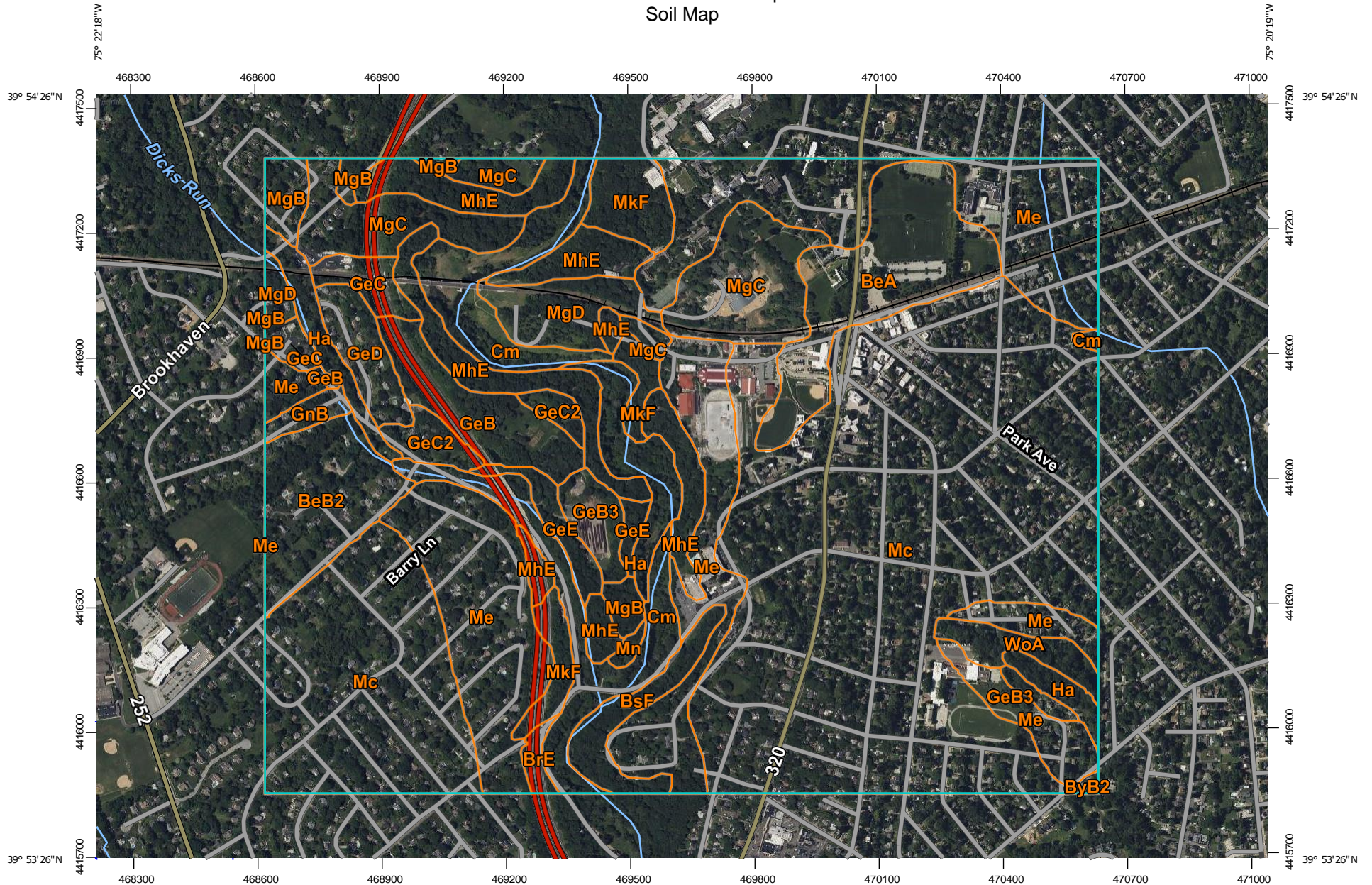
SECTION 7

EROSION AND SEDIMENT CONTROL, GP-11 PLAN

Due to the construction methods and materials, no erosion or sediment impacts are proposed. Materials will be stored off site, inside Swarthmore College's engineering building. During construction, materials will be driven to the site. If the ground is saturated, materials will be carried in by hand. If the ground is dry, a work vehicle will be driven to the trail through a mowed grass field. The access path is displayed in the Site Plan Maps labeled as "disturbance".

The only proposed soil impact is the placement of mudsills which will require the removal of no more than 8" depth of soil across 6' for the leveling of each sill. This soil will be removed using hand tools including a pick-mattock and mcleod. Excess soil will be tamped into lower sections. Once the mud sills are in place, there will be no further soil removed or impacted.

Custom Soil Resource Report Soil Map




Map Scale: 1:12,900 if printed on A landscape (11" x 8.5") sheet.

0 150 300 600 900 Meters
0 500 1000 2000 3000 Feet


Map projection: Web Mercator Corner coordinates: WGS84 Edgetics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

 Soil Map Unit Polygons


 Soil Map Unit Lines


 Soil Map Unit Points

Special Point Features


 Blowout

 Borrow Pit


 Clay Spot


 Closed Depression

 Gravel Pit

 Gravelly Spot


 Landfill

 Lava Flow

 Marsh or swamp

 Mine or Quarry

 Miscellaneous Water

 Perennial Water

 Rock Outcrop

 Saline Spot

 Sandy Spot

 Severely Eroded Spot


 Sinkhole

 Slide or Slip


 Sodic Spot


 Spoil Area

 Stony Spot


 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

Water Features

 Streams and Canals

Transportation

 Rails


 Interstate Highways

 US Routes

 Major Roads

 Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service

Web Soil Survey URL:

Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Delaware County, Pennsylvania

Survey Area Data: Version 20, Sep 6, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 5, 2022—Jul 4, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BeA	Beltsville silt loam, 0 to 3 percent slopes	36.7	4.8%
BeB2	Beltsville silt loam, 3 to 8 percent slopes, moderately eroded	24.7	3.2%
BrE	Brandywine loam, 25 to 40 percent slopes	2.1	0.3%
BsF	Brandywine very stony loam, 25 to 50 percent slopes	10.3	1.3%
ByB2	Butlertown silt loam, 3 to 8 percent slopes, moderately eroded	0.6	0.1%
Cm	Codorus silt loam	41.9	5.5%
GeB	Glenelg channery loam, 3 to 8 percent slopes	17.9	2.4%
GeB3	Glenelg channery silt loam, 3 to 8 percent slopes, severely eroded	8.5	1.1%
GeC	Glenelg channery silt loam, 8 to 15 percent slopes	8.2	1.1%
GeC2	Glenelg channery silt loam, 8 to 15 percent slopes, moderately eroded	7.7	1.0%
GeD	Glenelg channery silt loam, 15 to 25 percent slopes	9.4	1.2%
GeE	Glenelg channery silt loam, 25 to 35 percent slopes	7.2	0.9%
GnB	Glenville silt loam, 3 to 8 percent slopes	3.2	0.4%
Ha	Hatboro silt loam	22.9	3.0%
Mc	Made land, silt and clay materials	285.6	37.5%
Me	Made land, schist and gneiss materials	138.4	18.2%
MgB	Manor loam, 3 to 8 percent slopes	9.5	1.2%
MgC	Manor loam, 8 to 15 percent slopes	42.8	5.6%
MgD	Manor loam, 15 to 25 percent slopes	14.9	2.0%
MhE	Manor loam and channery loam, 25 to 35 percent slopes	43.4	5.7%
MkF	Manor soils, 35 to 60 percent slopes	18.0	2.4%
Mn	Melvin silt loam	1.1	0.1%

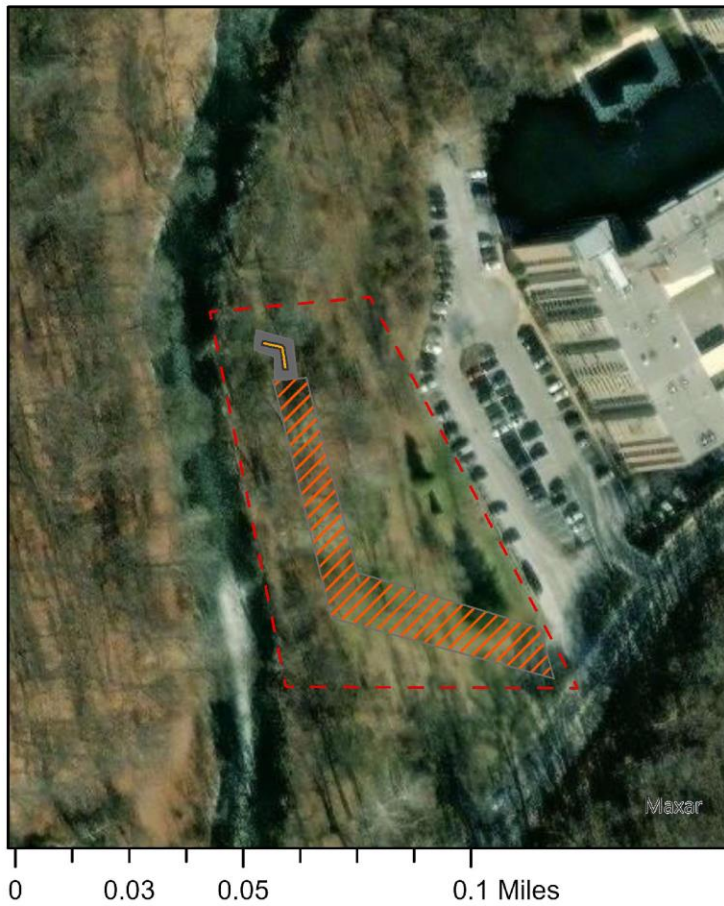


Figure 1. Imagery map depicting project bounds, area of disturbance, and boardwalk location

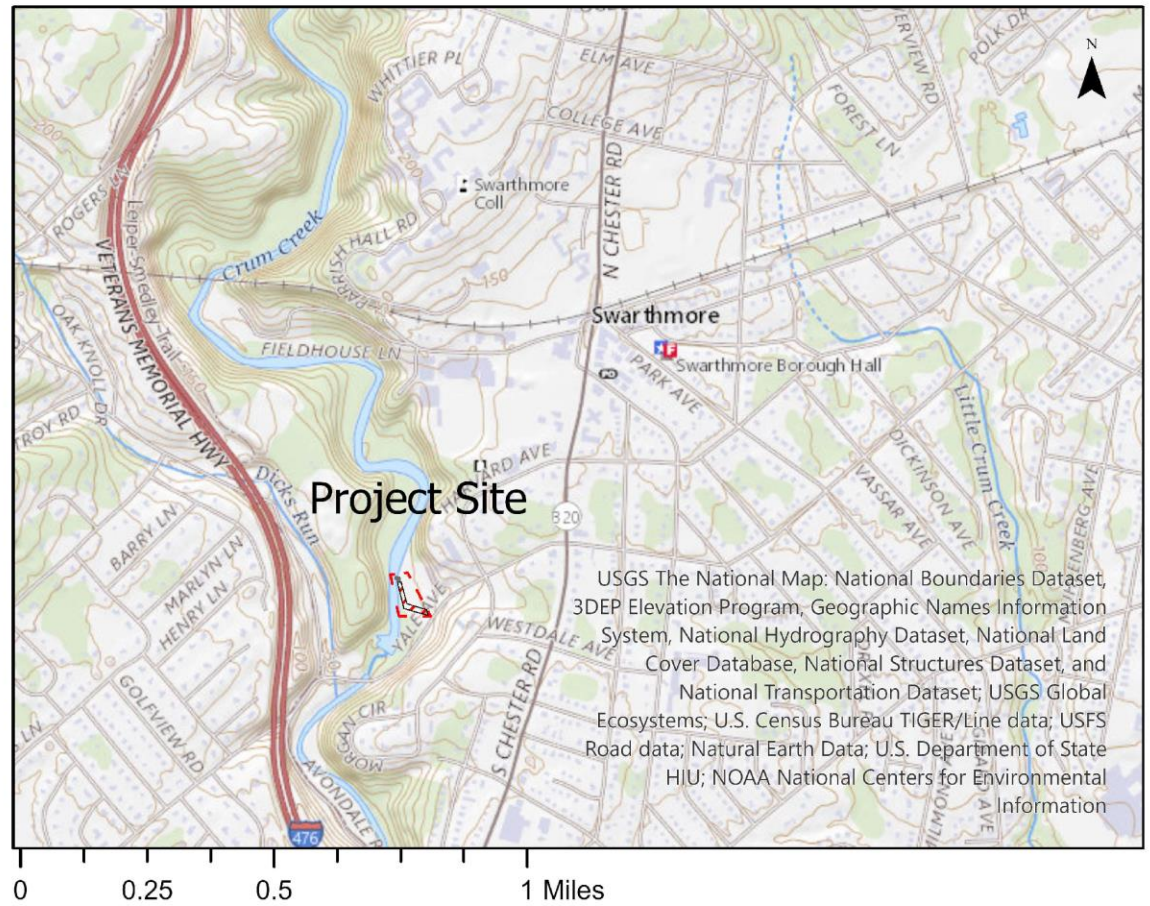
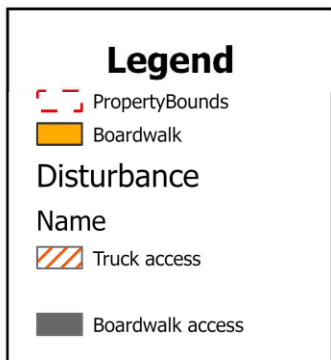


Figure 2. Topographic Map of Project Site location in relation to Swarthmore



Swarthmore College
 Engineering Senior Project
 Crum Woods Boardwalk E&S Map
 Emily van Assendelft
 Jonah Ring
 March 6, 2023

SECTION 8

PNDI SEARCH RECEIPT AND CLEARANCES

1. PROJECT INFORMATION

Project Name: **Swarthmore College Final Engineering Project - Crum Creek Trail Boardwalk**

Date of Review: **2/9/2023 11:22:24 PM**

Project Category: **Recreation, Trails & Trailheads (parking, etc.)**

Project Area: **0.03 acres**

County(s): **Delaware**

Township/Municipality(s): **SWARTHMORE**

ZIP Code:

Quadrangle Name(s): **LANSDOWNE**

Watersheds HUC 8: **Lower Delaware**

Watersheds HUC 12: **Crum Creek**

Decimal Degrees: **39.896506, -75.356073**

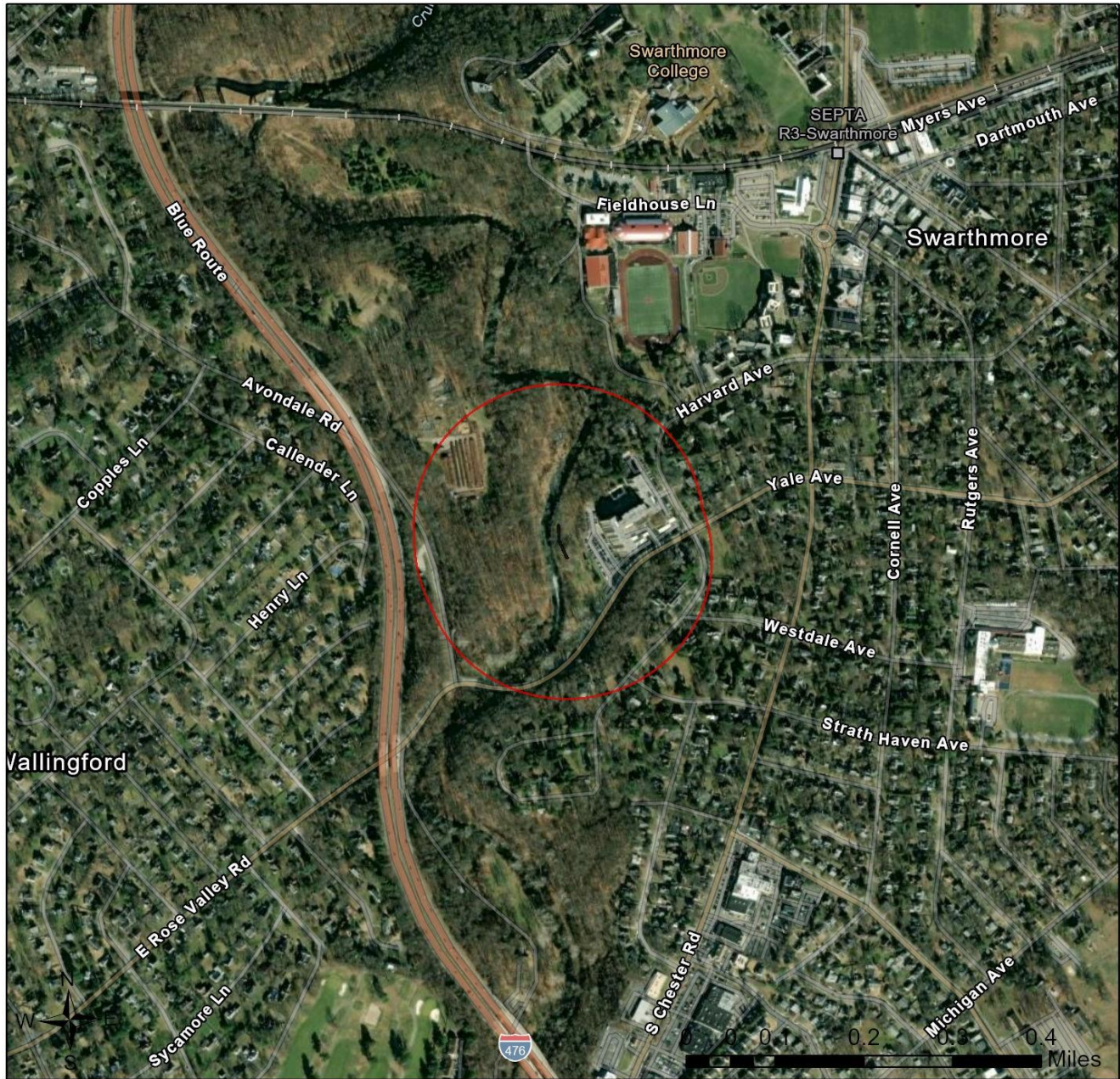
Degrees Minutes Seconds: **39° 53' 47.4202" N, 75° 21' 21.8623" W**



2. SEARCH RESULTS

Agency	Results	Response
PA Game Commission	No Known Impact	No Further Review Required
PA Department of Conservation and Natural Resources	Potential Impact	FURTHER REVIEW IS REQUIRED, See Agency Response
PA Fish and Boat Commission	Potential Impact	FURTHER REVIEW IS REQUIRED, See Agency Response
U.S. Fish and Wildlife Service	No Known Impact	No Further Review Required

As summarized above, Pennsylvania Natural Diversity Inventory (PNDI) records indicate there may be potential impacts to threatened and endangered and/or special concern species and resources within the project area. If the response above indicates "No Further Review Required" no additional communication with the respective agency is required. If the response is "Further Review Required" or "See Agency Response," refer to the appropriate agency comments below. Please see the DEP Information Section of this receipt if a PA Department of Environmental Protection Permit is required.

Swarthmore College Final Engineering Project - Crum Creek Trail Boardwalk

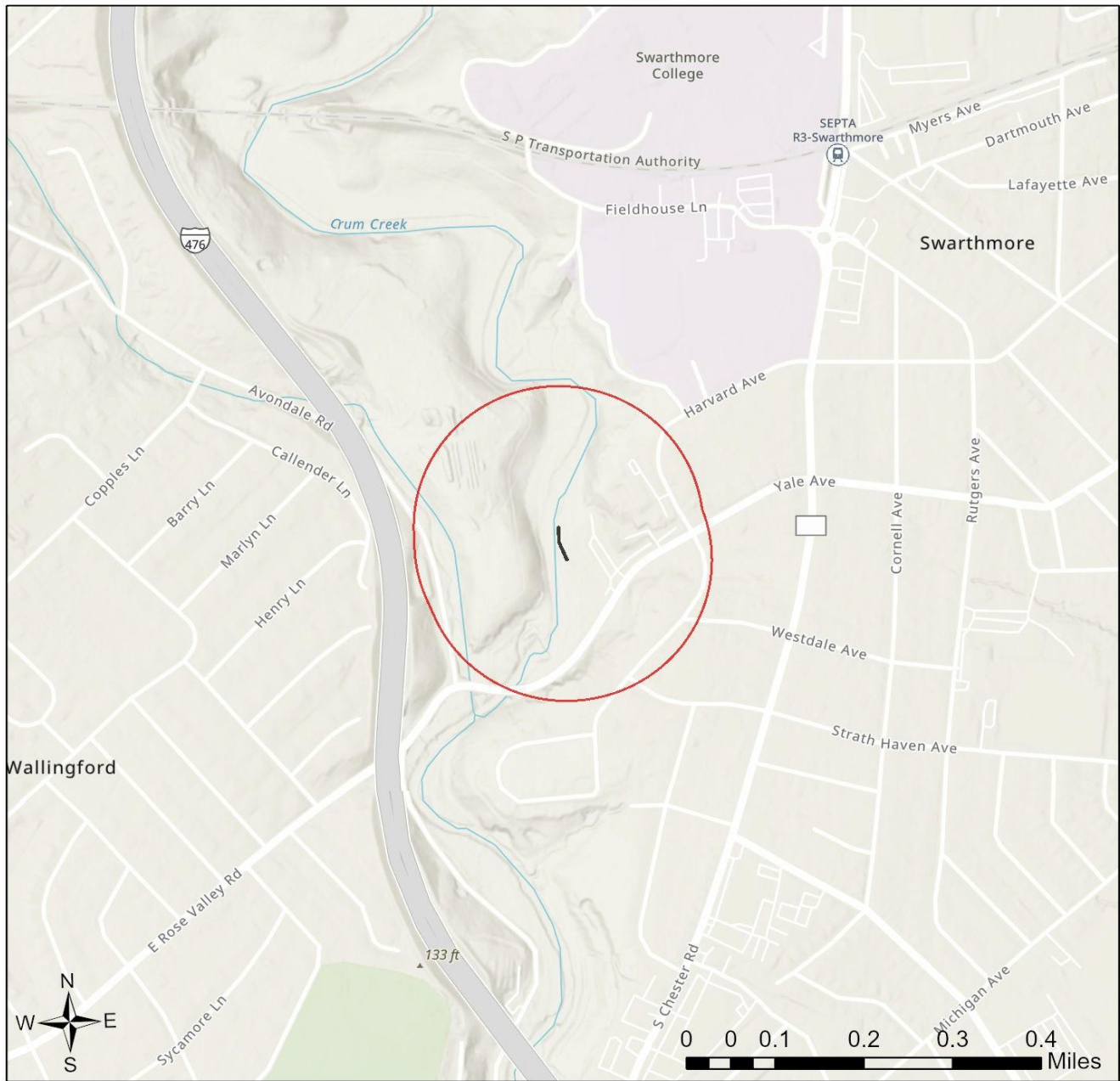




-  Buffered Project Boundary
-  Project Boundary



Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

Swarthmore College Final Engineering Project - Crum Creek Trail Boardwalk



-  Buffered Project Boundary
-  Project Boundary



Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

RESPONSE TO QUESTION(S) ASKED

Q1: Will the entire project area (including any discharge), plus a 300 feet buffer around the project area, all occur in or on an existing building, parking lot, driveway, road, road shoulder, street, runway, paved area, railroad bed, maintained (periodically mown) lawn, crop agriculture field or maintained orchard?

Your answer is: No

Q2: Accurately describe what is known about wetland presence in the project area or on the land parcel. "Project" includes all features of the project (including buildings, roads, utility lines, outfall and intake structures, wells, stormwater retention/detention basins, parking lots, driveways, lawns, etc.), as well as all associated impacts (e.g., temporary staging areas, work areas, temporary road crossings, areas subject to grading or clearing, etc.). Include all areas that will be permanently or temporarily affected -- either directly or indirectly -- by any type of disturbance (e.g., land clearing, grading, tree removal, flooding, etc.). Land parcel = the lot(s) on which some type of project(s) or activity(s) are proposed to occur.

Your answer is: The project area (or land parcel) has not been investigated by someone qualified to identify and delineate wetlands (holding a natural resource degree or equivalent work experience), or it is currently unknown if the project or project activities will affect wetlands.

Q3: Aquatic habitat (stream, river, lake, pond, etc.) is located on or adjacent to the subject property and project activities (including discharge) may occur within 300 feet of these habitats?

Your answer is: Yes

3. AGENCY COMMENTS

Regardless of whether a DEP permit is necessary for this proposed project, any potential impacts to threatened and endangered species and/or special concern species and resources must be resolved with the appropriate jurisdictional agency. In some cases, a permit or authorization from the jurisdictional agency may be needed if adverse impacts to these species and habitats cannot be avoided.

These agency determinations and responses are **valid for two years** (from the date of the review), and are based on the project information that was provided, including the exact project location; the project type, description, and features; and any responses to questions that were generated during this search. If any of the following change: 1) project location, 2) project size or configuration, 3) project type, or 4) responses to the questions that were asked during the online review, the results of this review are not valid, and the review must be searched again via the PNDI Environmental Review Tool and resubmitted to the jurisdictional agencies. The PNDI tool is a primary screening tool, and a desktop review may reveal more or fewer impacts than what is listed on this PNDI receipt. The jurisdictional agencies **strongly advise against** conducting surveys for the species listed on the receipt prior to consultation with the agencies.

PA Game Commission

RESPONSE:

No Impact is anticipated to threatened and endangered species and/or special concern species and resources.

PA Department of Conservation and Natural Resources

RESPONSE:

Further review of this project is necessary to resolve the potential impact(s). Please send project information to this agency for review (see WHAT TO SEND).

DCNR Species: (Note: The Pennsylvania Conservation Explorer tool is a primary screening tool, and a desktop review may reveal more or fewer species than what is listed below. After desktop review, if a botanical survey is required by DCNR, we recommend the DCNR Botanical Survey Protocols, available here:

<https://conservationexplorer.dcnr.pa.gov/content/survey-protocols>)

Scientific Name	Common Name	Current Status	Proposed Status	Survey Window
Quercus falcata	Southern Red Oak	Endangered	Endangered	Flowers April - May; leaves distinctive

PA Fish and Boat Commission

RESPONSE:

Further review of this project is necessary to resolve the potential impact(s). Please send project information to this agency for review (see WHAT TO SEND).

PFBC Species: (Note: The Pennsylvania Conservation Explorer tool is a primary screening tool, and a desktop review may reveal more or fewer species than what is listed below.)

Scientific Name	Common Name	Current Status
Sensitive Species**		Threatened

U.S. Fish and Wildlife Service

RESPONSE:

No impacts to **federally** listed or proposed species are anticipated. Therefore, no further consultation/coordination under the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq. is required. Because no take of federally listed species is anticipated, none is authorized. This response does not reflect potential Fish and Wildlife Service concerns under the Fish and Wildlife Coordination Act or other authorities.

* Special Concern Species or Resource - Plant or animal species classified as rare, tentatively undetermined or candidate as well as other taxa of conservation concern, significant natural communities, special concern populations (plants or animals) and unique geologic features.

** Sensitive Species - Species identified by the jurisdictional agency as collectible, having economic value, or being susceptible to decline as a result of visitation.

WHAT TO SEND TO JURISDICTIONAL AGENCIES

If project information was requested by one or more of the agencies above, upload* or email the following information to the agency(s) (see AGENCY CONTACT INFORMATION). Instructions for uploading project materials can be found [here](#). This option provides the applicant with the convenience of sending project materials to a single location accessible to all three state agencies (but not USFWS).

*If information was requested by USFWS, applicants must email, or mail, project information to IR1_ESPenn@fws.gov to initiate a review. USFWS will not accept uploaded project materials.

Check-list of Minimum Materials to be submitted:

___ Project narrative with a description of the overall project, the work to be performed, current physical characteristics of the site and acreage to be impacted.

___ A map with the project boundary and/or a basic site plan (particularly showing the relationship of the project to the physical features such as wetlands, streams, ponds, rock outcrops, etc.)

In addition to the materials listed above, USFWS REQUIRES the following

___ **SIGNED** copy of a Final Project Environmental Review Receipt

The inclusion of the following information may expedite the review process.

___ Color photos keyed to the basic site plan (i.e. showing on the site plan where and in what direction each photo was taken and the date of the photos)

___ Information about the presence and location of wetlands in the project area, and how this was determined (e.g., by a qualified wetlands biologist), if wetlands are present in the project area, provide project plans showing the location of all project features, as well as wetlands and streams.

4. DEP INFORMATION

The Pa Department of Environmental Protection (DEP) requires that a signed copy of this receipt, along with any required documentation from jurisdictional agencies concerning resolution of potential impacts, be submitted with applications for permits requiring PNDI review. Two review options are available to permit applicants for handling PNDI coordination in conjunction with DEP's permit review process involving either T&E Species or species of special concern. Under sequential review, the permit applicant performs a PNDI screening and completes all coordination with the appropriate jurisdictional agencies prior to submitting the permit application. The applicant will include with its application, both a PNDI receipt and/or a clearance letter from the jurisdictional agency if the PNDI Receipt shows a Potential Impact to a species or the applicant chooses to obtain letters directly from the jurisdictional agencies. Under concurrent review, DEP, where feasible, will allow technical review of the permit to occur concurrently with the T&E species consultation with the jurisdictional agency. The applicant must still supply a copy of the PNDI Receipt with its permit application. The PNDI Receipt should also be submitted to the appropriate agency according to directions on the PNDI Receipt. The applicant and the jurisdictional agency will work together to resolve the potential impact(s). See the DEP PNDI policy at <https://conservationexplorer.dcnr.pa.gov/content/resources>.



5. ADDITIONAL INFORMATION

The PNDI environmental review website is a preliminary screening tool. There are often delays in updating species status classifications. Because the proposed status represents the best available information regarding the conservation status of the species, state jurisdictional agency staff give the proposed statuses at least the same consideration as the current legal status. If surveys or further information reveal that a threatened and endangered and/or special concern species and resources exist in your project area, contact the appropriate jurisdictional agency/agencies immediately to identify and resolve any impacts.

For a list of species known to occur in the county where your project is located, please see the species lists by county found on the PA Natural Heritage Program (PNHP) home page (www.naturalheritage.state.pa.us). Also note that the PNDI Environmental Review Tool only contains information about species occurrences that have actually been reported to the PNHP.

6. AGENCY CONTACT INFORMATION

PA Department of Conservation and Natural Resources

Bureau of Forestry, Ecological Services Section
400 Market Street, PO Box 8552
Harrisburg, PA 17105-8552
Email: RA-HeritageReview@pa.gov

PA Fish and Boat Commission

Division of Environmental Services
595 E. Rolling Ridge Dr., Bellefonte, PA 16823
Email: RA-FBPACENOTIFY@pa.gov

U.S. Fish and Wildlife Service

Pennsylvania Field Office
Endangered Species Section
110 Radnor Rd; Suite 101
State College, PA 16801
Email: IR1_ESPenn@fws.gov
NO Faxes Please

PA Game Commission

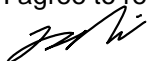
Bureau of Wildlife Management
Division of Environmental Review
2001 Elmerton Avenue, Harrisburg, PA 17110-9797
Email: RA-PGC_PNDI@pa.gov
NO Faxes Please

7. PROJECT CONTACT INFORMATION

Name: Jonah Ring
Company/Business Name: Swarthmore College
Address: 500 College Ave.
City, State, Zip: Swarthmore, Pa, 19081
Phone: (818) 823-1193 Fax: ()
Email: jring1@swarthmore.edu

8. CERTIFICATION

I certify that ALL of the project information contained in this receipt (including project location, project size/configuration, project type, answers to questions) is true, accurate and complete. In addition, if the project type, location, size or configuration changes, or if the answers to any questions that were asked during this online review change, I agree to re-do the online environmental review.



applicant/project proponent signature

2/12/23

date



February 13, 2023

IN REPLY REFER TO

SIR# 57097

Swarthmore College
Jonah Ring
500 College Avenue
Swarthmore, Pennsylvania 19081

**RE: Species Impact Review (SIR) – Rare, Candidate, Threatened and Endangered Species
PNDI Search No. 773252_3
Swarthmore College Final Engineering Project - Crum Creek Trail Boardwalk
Swarthmore Borough: DELAWARE County**

Dear Jonah Ring:

This responds to your inquiry about a Pennsylvania Natural Diversity Inventory (PNDI) Internet Database search “potential conflict” or a threatened and endangered species impact review. These projects are screened for potential conflicts with rare, candidate, threatened or endangered species under Pennsylvania Fish and Boat Commission jurisdiction (fish, reptiles, amphibians, aquatic invertebrates only) using the Pennsylvania Natural Diversity Inventory (PNDI) database and our own files. These species of special concern are listed under the Endangered Species Act of 1973, the Wild Resource Conservation Act, and the Pennsylvania Fish and Boat Code (Chapter 75), or the Wildlife Code.

An element occurrence of a rare, candidate, threatened, or endangered species under our jurisdiction is known from the vicinity of the proposed project. However, given the nature of the proposed project, the immediate location, or the current status of the nearby element occurrence(s), no adverse impacts are expected to the species of special concern.

This response represents the most up-to-date summary of the PNDI data and our files and is valid for two (2) years from the date of this letter. An absence of recorded species information does not necessarily imply species absence. Our data files and the PNDI system are continuously being updated with species occurrence information. Should project plans change or additional information on listed or proposed species become available, this determination may be reconsidered, and consultation shall be re-initiated.

If you have any questions regarding this review, please contact Kathy Gipe at 814-359-5186 or kgipe@pa.gov and refer to the SIR # 57097. Thank you for your cooperation and attention to this important matter of species conservation and habitat protection.

Sincerely,

A handwritten signature in black ink that reads "Christopher A. Urban". The signature is written in a cursive style with a large, prominent initial "C".

Christopher A. Urban, Chief
Natural Diversity Section

CAU//KDG/dn

BUREAU OF FORESTRY

February 10, 2023

PNDI Number: 773252

Version: Final_3; 2/9/23

Jonah Ring
Swarthmore College
500 College Ave.
Swarthmore, PA 19081
Email: jring1@swarthmore.edu (hard copy will not follow)

**Re: UPDATE - Swarthmore College Final Engineering Project - Crum Creek Trail Boardwalk
Swarthmore Borough, Delaware County, PA**

Dear Jonah Ring,

Thank you for the submission of the Pennsylvania Natural Diversity Inventory (PNDI) Environmental Review Receipt Number **773252 (Final_3)** for review. PA Department of Conservation and Natural Resources screened this project for potential impacts to species and resources under DCNR's responsibility, which includes plants, terrestrial invertebrates, natural communities, and geologic features only.

No Impact Anticipated

PNDI records indicate species or resources under DCNR's jurisdiction are located in the vicinity of the project. However, based on the information you submitted concerning the nature of the project, and that vegetation disturbance will be minimal with no tree cutting required, DCNR has determined that no impact is likely. No further coordination with our agency is needed for this project.

Recommended Best Management Practices:

- Use a conservative approach to project design that minimizes permanent and temporary disturbances to soil and native vegetation. This will conserve habitat and limit opportunities for invasive plants.
- Clean boot treads, tools, construction equipment, and vehicles thoroughly (especially the undercarriage and wheels) before they are brought on site. This will remove invasive plant seeds and invasive earthworms/cocoons that may have been picked up at other worksites.
- Use clean project materials to avoid introducing invasive species from contaminated sources.
- If seeding, do not use seed mixes that include invasive species. More information about invasive plants in Pennsylvania can be found at the following link:
<http://www.dcnr.pa.gov/Conservation/WildPlants/InvasivePlants/Pages/default.aspx>
- If seeding, use habitat-appropriate native seed mixes when possible. For example, use a riparian seed mix when reseeded along a waterway. The Bureau of Forestry Planting & Seeding Guidelines can be found at the following link for recommendations: http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_20031083.pdf

This response represents the most up-to-date review of the PNDI data files and is valid for two (2) years only. If project plans change or more information on listed or proposed species becomes available, our determination may be reconsidered. Should the proposed work continue beyond the period covered by this letter and a permit has not

been acquired, please resubmit the project to this agency as an "Update" (including an updated PNDI receipt, project narrative, description of project changes and accurate map). As a reminder, this finding applies to potential impacts under DCNR's jurisdiction only. Visit the PNHP website for directions on contacting the Commonwealth's other resource agencies for environmental review.

Should you have any questions or concerns, please contact Stephanie Seymour, Ecological Information Specialist, by phone (717-705-2819) or via email (c-steseymo@pa.gov).

Sincerely,

A handwritten signature in black ink that reads "Greg Podniesinski". The signature is written in a cursive style and is centered within a light gray rectangular box.

Greg Podniesinski, Section Chief
Natural Heritage Section

C) USFS Standard Puncheon Specifications

STANDARD PUNCHEON

TYPICAL ID	STRINGER/MUD SILL				DECK/BACKWALL				CURB				WEARING SURFACE				COMMENTS
	SIZE	SPECIES	NUMBER	PRESERV. TYPE	TYPE	SIZE	SPECIES	PRESERV. TYPE	SIZE	SPECIES	PRESERV. TYPE	TYPE	SIZE	SPECIES	PRESERV. TYPE		
SP1-1				P				P									

N/A WHEN NOT APPLICABLE

ELEVATION VIEW

TYPICAL SECTION

PLAN VIEW

NOTES:

- PRE-DRILL HOLES FOR FASTENERS TO PREVENT SPLITTING OF LOGS OR SAWN TIMBERS.
- RECESS END OF REBAR 1/2 INCH BELOW TOP OF STRINGERS.
- COMPACT BACKFILL IN 6 INCH LIFTS UNTIL NO VISUAL DISPLACEMENT.
- ALL FIELD DRILLED HOLES AND CUTS SHALL BE FIELD TREATED.
- FINAL DECK ELEVATION FOR RUNNING PLANKS OR DECKING SHALL BE NO MORE THAN 1/2 INCH DIFFERENCE IN ELEVATION.

PRESERVATIVE TREATMENT - (REFER TO AWPA USE CATEGORY SYSTEM)			
PRESERVATIVE TYPE	TREATMENT TYPE	USE CATEGORY	COMMENTS
P1	WB	UC4A	
P2	WB	UC3B	
P3			

TREATMENT TYPE: WB = WATERBORNE, OT = OIL-BORNE

USE CATEGORY: UC3B = ABOVE GROUND - EXPOSED, UC4A = GROUND CONTACT - GENERAL USE, UC4B = GROUND CONTACT - HEAVY DUTY

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE STANDARD TRAIL PLAN	PROJECT NAME & LOCATION STANDARD PUNCHEON	DRAWING NO. 934 - PUNCHEONS	TYPICAL ID SP1	REVISION DATE XX/XX/XX	DRAWING NO. STD_934-10-01
		SECTION	NO SCALE	SHEET 1 OF 2	OF

MUD SILL AND STRINGER LAYOUT

LOG STRINGER DETAIL

MUD SILL DETAIL

TREAD STRIP DETAIL

DRAIN SLOT DETAIL

TYPICAL LAP JOINT

T = THICKNESS OF RETAINER

TYPICAL BUTT JOINT

SHEET 2 OF 2

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE STANDARD TRAIL PLAN	PROJECT NAME & LOCATION STANDARD PUNCHEON	DRAWING NO. 934 - PUNCHEONS	TYPICAL ID SP2	REVISION DATE XX/XX/XX	DRAWING NO. STD_934-10-02
		SECTION	NO SCALE	SHEET 1 OF 2	OF